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Xerox: The quest for quality continues

Contract manufacturers and surface mount technology

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Why Computervision's Gable is not out of the woods yet

Canadian Electronics

Electronic Business

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Sales growth has a foreign ring

Foreign sales may keep U.S. companies' sales advancing this year. Profits are another story

In most industries it may be a habit to push shipments out the door at the end of the fiscal year. In the electronics industry it is a passion that has been developed into an art. Since most electronics companies are on a calendar year, sales peak in the fourth quarter, followed by the second quarter push, by companies whose year ends in June. Every year since 1975 when ELECTRONIC BUSINESS started tracking sales and profits by U.S. electronics companies and distilling them into the indexes that appear on this page, fourth quarter sales have surpassed the previous three. So it was not surprising that the index for revenue ended the 1986 year at its highest value ever.

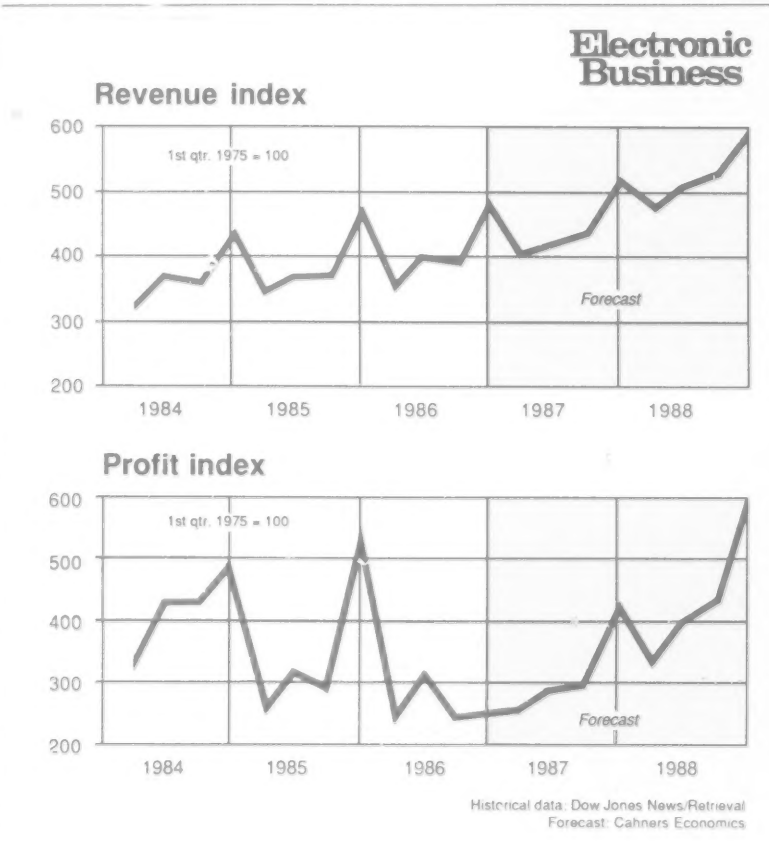
What was surprising is that the fourth quarter peak in sales was relatively modest — less than 2% higher than 1985's and only 22% higher than the second quarter. Thus, revenue for 1986 was ahead of revenue for 1985 by a meager 4%, the smallest annual growth since we started the index, earning for 1986, for most companies, the dubious reputation of having been the most difficult year in recent memory.

Moreover, the main engine that propelled sales last year was outside the country. Had it not been for its foreign sales, IBM would had seen a decline in revenue last year for the first time in more than four decades. As it was, it registered only a gain of slightly more than 2% for the year. The fourth quarter did not help, as revenue was off 1% with respect to the year-earlier quarter. Foreign orders grew by 30% for Hewlett-Packard in November and December, according to president John A. Young. Among the 16 companies that make up the industry sample on whose revenue and profits we base our indexes, the major one whose sales growth in the United States matched growth from international sales was Digital Equipment Corp. It is likely that this scenario will be repeated in 1987. Indeed, many companies pin their hopes for 1987 on foreign sales and look to the weak dollar as a major weapon to gain foreign orders.

Profits are another story. The index for profits declined by 25% last year with respect to 1985. That year, in turn, had seen profits drop by 17% with respect to the record year 1984. The index reflected not only IBM's eroding profits — they dropped 27% in 1986 — but also the red ink at semiconductor companies. The semiconductor segment, however, will probably be the first to recover in 1987. Although profits by chip makers will be under severe pressure from low chip prices, at least growing sales promise to lift their income into the black.

Using the Cahners Early Warning Indicator, Cahners economist Cheryl Patstone forecasts a 10% growth in revenue by a much better improvement, 21% in profits. Judging by brisk sales in the first quarter, Patstone's forecast may turn out to be on the mark. Proof is coming soon, when the figures for the first quarter of 1987 become available later this month.

ALBERTO SOCOLOVSKY



Historical data: Dow Jones News/Retrieval
Forecast: Cahners Economics

Steady growth expected

The United States Index of Industrial Production, a coincident indicator of the U.S. economy, showed a mild decline in the second quarter, followed by a slight recovery in the third quarter. For 1986, production is expected to be up a scant 0.9% from the previous year. This year, steady improvements are forecast thoughout the year pushing production up 3.9%.

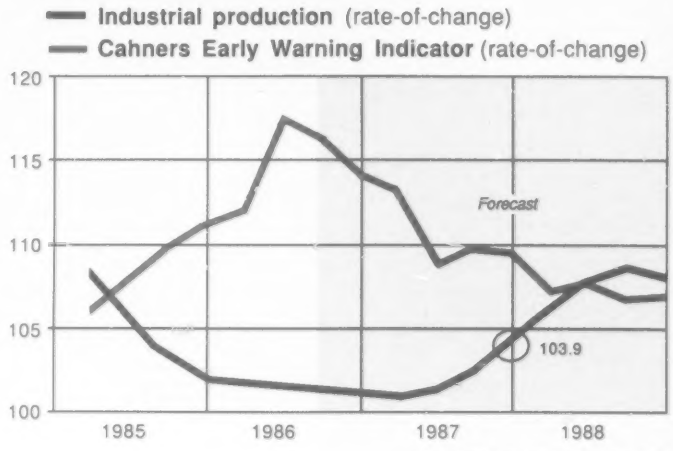
The Cahners Early Warning Indicator (CEWI) is a weighted average of housing starts, the Dow Jones Industrial Stock Index and the money supply (M2) — deflated by the Consumer Price Index. It forecasts probable business cycles about 12 months in advance. The black curve is a plot of the 12-month rate of change Index of Industrial Production. That is, its change over a 12-month period can be determined by comparison with the line at 100. For example, the 103.9 level forecasts using the CEWI for the end of this year indicates that the average for all of 1987 should be 3.9% above 1986.

Readers can obtain a brochure explaining the CEWI method from Cheryl Patstone, economist, Cahners Economics Department, 3021 Tisch Way, Suite 100, San Jose, Calif. 95128.

ATE revenue and profit

In the third quarter of 1986, revenue for automatic test equipment manufacturers showed an 8% increase from the prior quarter and was up 9% from the year-ago quarter. This was the first quarter-to-quarter gain since the beginning of 1985. The gradual improvement in the third quarter along with fourth quarter revenue is expected to show an even sharper increase when demand from computer and semiconductor manufacturers for automatic test equipment strengthens, which seems to signal a climate of cautious expansion. Following a strong 42.4% gain in 1984, sales fell 14.4% in 1985. Despite a gradual improvement in the second half of 1986, revenue is expected to drop 2.7%. This year a 12.2% increase is forecast, followed by a sharp 25.3% rise in 1988. Earnings of ATE manufacturers showed a slight profit for the first time in over a year. Profits are expected to continue to strengthen throughout the next two years.

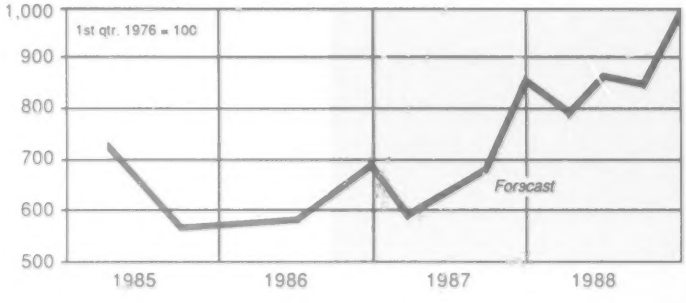
Economic indicators



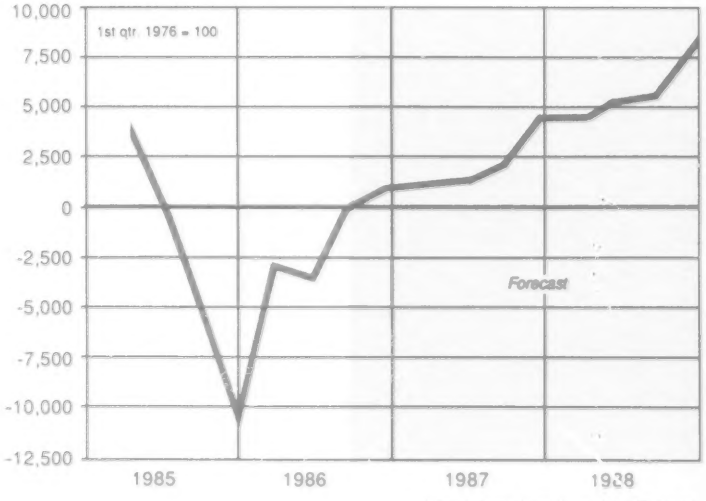
Historical data: Federal Reserve Board
Forecast: Cahners Economics

ATE indexes

Revenue



Profits



Historical data: Dow Jones News/Retrieval
Forecast: Cahners Economics

Surface mount technology is reviving contract assembly

Contract manufacturers are investing heavily in SMT. Already, many say they are reaping the rewards

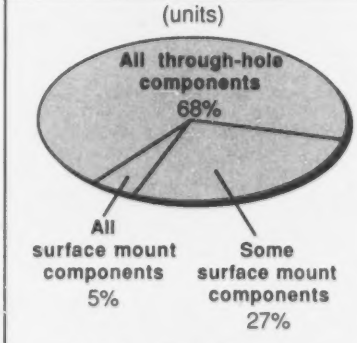
U.S. contract assembly houses, already benefiting from a strategic industry-wide move back to domestic manufacturing [ELECTRONIC BUSINESS Sept. 15, 1986 p28], are opening another market window that promises to accelerate the trend toward onshore production. That window is surface mount technology (SMT), assembling components directly on the surface of a printed circuit board (PCB), rather than soldering them through plated holes. The result is smaller, denser, higher performance PCBs.

Although SMT is a complex, process-intensive technique, involving ultratight design rules, expensive and often unreliable machinery, and a paucity of packaging standards, most large contract manufacturers say that they have invested millions of dollars over the past two to three years to bring on full SMT production capability. The risks are great, contractors concede, but the risks of remaining on the sidelines are greater. Even though the big push to SMT has yet to reach full steam — only 3% of all integrated circuits (ICs) consumed last year were in surface mount packages — those contract manufacturers that have taken the plunge report that SMT is by far the fastest-growing segment of their businesses, with computer, peripherals and telecommunications applications leading the way.

"Anytime you have a major transition phase in the interconnection industry, the independent contract people can flourish," says Harvey Miller, a Palo Alto, Calif., consultant. Adds Charles Henri-Mangin of Ceeris International, a Connecticut-based research firm: "The transition should last until the end of the decade. Even for the job shops that are just starting along the learning curve, there is a terrific opportunity. A lot of their customers want to eliminate their overhead but keep design and manufacturing close to home. The SMT phenomenon makes those factors that much more important."

Winston Chen, the president of Solectron Corp., a San Jose, California-based contract house with 1986 revenue of just under $60 million, believes SMT is his ticket to growth and profitability. Last year, SMT-related revenue was about $12 million, up from roughly $3 million in 1985. By the end of 1987, Solectron will have invested $6 million in surface mount hardware, software and training, with the aim of expanding from computers and peripherals to the medical instrumentation and telecommunications markets.

Shipments of PCBs by U.S. contract manufacturers*



Total 1986 shipments
22.6 million boards

*Based on a survey of the 50 largest U.S. contract assembly houses

Source: Gnostic Concepts Inc.

"It takes at least three years to perfect the SMT process," argues Chen. "The bare minimum entry fee is $1 million with a required investment of $3 million to $5 million to reach reasonable volume, plus the necessity of having substantial expertise in applied physics and chemistry. As a small or medium size OEM [original equipment manufacturer] wouldn't you rather utilize your limited assets in marketing and product development?"

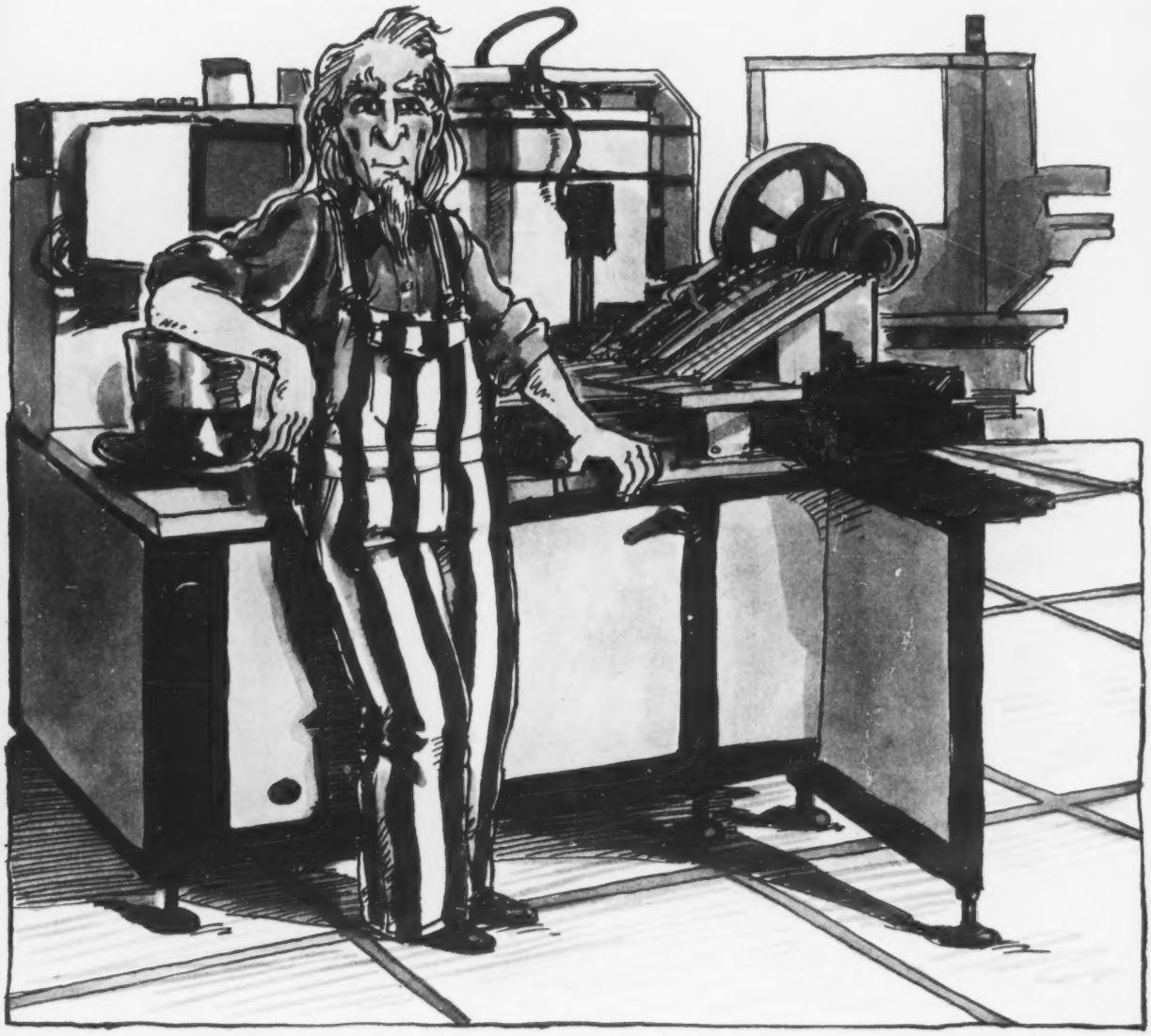
Chen acknowledges that some operations managers are reluctant to relinquish control over manufacturing to a contractor, but he insists most of his customers no longer have the luxury of a choice. "The electronics market is fluctuating more wildly than ever, and without assurance that you'll experience two years of steady growth, you need to look to a job shop for protection."

Cloning procedures

SCI Systems Inc., the largest U.S turnkey contract manufacturer, has made a big move to SMT at its main plant in Huntsville, Ala., and at its SCI Manufacturing group in Sunnyvale, Calif. The company claims it has the worldwide capacity to handle placement of 2.5 million surface mount parts a day. It is reportedly stuffing surface-mounted boards for IBM's soon to be introduced 286-based microcomputer, among other large contracts.

Walter Conroy, vice president and general manager of SCI Manufacturing, says that of the top 20 electronics companies, generating a total of some $150 billion in volume, SCI is working with at least 15 of them in surface mount. SCI Manufacturing consists of four recent acquisitions: Puosto Inc.'s Unitronic operation and AWI Inc., which are specialty SMT assemblers; Ouitest Inc., a board test company; and Nugraphix Inc., an SMT design center. "These acquisitions brought a lot of expertise [to SCI], particularly in design," says Conroy. "We've got 80 people here working in that area. The major problem we encounter in surface mount is poorly designed boards. Now we're able to look at that design and quote a price at manufacturing. We can get involved at the earliest stage right through to test."

Conroy adds that SCI's ability to "clone factories" in terms of processes and equipment makes it possible to



Jon Mcintosh

design and prototype a board in the States and then assemble the board in volume at an SCI plant in Scotland or Singapore. This capability is essential in serving the disk drive industry, for example, because the industry has largely moved to the Far East. "Some people, like Maxtor or Seagate, will always go offshore for more labor-intensive electromechanical assembly. They need to be serviced locally."

ICI Array Technology, a San Jose design and assembly shop that was acquired a year ago by the giant Imperial Chemical Industries Plc. of Great Britain, has invested $3 million in SMT equipment and technology over the past three years. Today SMT represents about half of Array Technology's $16 million annual revenue. "We now understand issues like pad sizes [the surface-mounted part rests on a pad] and how much solder to dispense, and whether or not to use infrared or vapor phase soldering," explains vice president for marketing David Sear. "We know from looking at a board design whether it can be built with our process, without too much rework and touch-up. What this means is we have good feedback to manage our costs effectively."

SMT may be U.S. contract assembly houses' No. 1 weapon in battling offshore competition

Sear is among those trumpeting SMT as the No. 1 weapon in battling offshore competition. Resistors and other low-cost passive components currently make up the bulk of surface-mounted parts and thus Asian contractors have little leverage in component purchasing. Sear says that when ICs in small-outline packages and other surface mount configurations begin to proliferate, "I may look to set up an offshore purchasing office, but at this point when I look at the quotes we make against the offshore assemblers, we do pretty well."

"Disk and tape drives and other high-volume operations may go to overseas subcontractors," says Winston Chen of Solectron. "But in a customized, information-intensive business like SMT, where flexibility and quality are the keys, a well-managed domestic job shop has the advantage."

Inventory concerns

Still other U.S. contractors indicate that implementing just-in-time inventories can be a problem with offshore sourcing, as shipments can take up to

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two weeks by sea. In surface mount assembly, the problem is more severe, since the cost of inventory — both ICs and finished boards — is greater. Roger Main, president of Newark, New York-based IEC Electronics Corp., a $14 million contract house that has made a large investment in surface mounting, recalls one U.S. customer that ended up with tens of thousands of defective boards because of an overseas communications snafu. "With the complex layout and process requirements, you can't afford those kind of mistakes with SMT," Main concludes.

Those U.S. contractors eyeing overseas assembly say that they are only doing so for strategic reasons. Jim Hays, director for marketing of special programs at Avco Electronics Textron, with about $100 million in contract revenue (roughly $10 million in SMT), insists that "to be a world-class design-to-delivery company, you have to be a global competitor. The IBMs and Digital Equipments are worldwide, and we have to go where they go if we want to build products for them." Avco, which held off implementing SMT for nearly two years, 10 months ago installed its first surface mount assembly lines. Hays says that methodical approach allowed Avco to shake out a lot of the bugs that plagued its competitors. "We started slow and maybe we missed some of the front-page advertising hype that the others got," he says. "But we worked out a lot of problems in soldering and other processes, and I don't think we lost any business." Hays says Avco has booked about seven major surface mount contracts since last spring.

> JIT inventories can be a problem with SMT offshore sourcing, as shipments can take up to two weeks

Even among those contract houses that are still sitting on the fence, there is a belief that, eventually, they will have to make the investment in SMT. Thomas Marcellas, vice president for research and development at the Rexnord Automation Electronic Operations Group in Hunt Valley, Md., insists that he is not "disappointed we didn't make the move earlier. We've done some training among our people, and we're a little smarter than we were two years ago, but we're in no hurry." Marcellas also says that the $22 million a year contract operation remains concerned with the lack of standards on package size and shape. Moreover, there are few standards on the proper mounting of those packages (for example, how much movement can be tolerated on the pad). "I'm more convinced now that we need to get started," says Marcellas, "but at $500,000 just for a prototyping capability, I'd like to see more of these issues solved."

As for the tiny specialty SMT shops that have sprung up since 1983, they continue to believe they can do any small job better than their larger counterparts. Henry Flajole, president of Advanced Surface Mount Devices Inc., says that his $2 million San Diego assembly house "does jobs the bigger companies can't do. This is a business for specialists and we have a four-year foundation in surface mount. There are no standards, no handbooks. You have to be very selective about the equipment you use. It's all trial and error. The bigger companies aren't doing the job very well."

Indeed, one contract assembler conceded that his first-pass yields on type 2 boards — which feature both surface mount and through-hole components — were running close to 80%, compared with 99% for all through-hole digital boards. He attributed the lower yields to poor accuracy of U.S.-made pick-and-place gear and "100 other process problems. We've got to get our yields to at least 90% on the first pass," he says.

However, when these sticky process problems are finally solved and gate arrays and other semicustom ICs in reliable SMT packages are plentiful, large customers that formerly relied on contract houses for high-volume production will begin bringing their SMT operations in house. Already the seeds are planted — IBM is said to have about two dozen SMT pick-and-place machines in Austin, Texas, and others such as AT&T (said to have about 20 high-speed placement machines) and General Motors are spending tens of millions of dollars on SMT for strategic purposes. Contract houses, of course, will still fill an ongoing need for prototyping services and for second sources to handle overflow, but, as analyst Harvey Miller says, "Once the product matures, generally the role of the contractor diminishes. Still, there's a pretty nice window over the next few years."

MARK MEHLER

Jockeying for position in low-cost logic analyzers

The low end of the logic analyzer market is only worth $40 million worldwide. But it's attracting some big names

At the low end of the logic analyzer market — worth about $40 million worldwide — instrument giants Gould Inc. and Tektronix Inc. are stepping up their efforts to establish a beachhead against Japanese competitors, including Matsushita's Panasonic Industrial Co.

Sales of all logic analyzers should reach $295 million this year, according to San Jose, Calif., market research firm Prime Data Inc. Although that is only a small portion of the $7 billion instrumentation market, it is the fastest growing segment, says Prime Data president Galen Wampler. He forecasts a 16% growth rate to the end of the decade. At the low end, where systems are often portable and cost under $8,000, that rate is 20%.

Technicians and engineers use logic analyzers to test and debug digital equipment, mainly microprocessor-based boards and controllers. They analyze the logic state or the timing of data channels inside the system at various stages of product life ranging from design and prototype to software integration and service.

Right now, the low end is dominated by tiny Arium Corp. of Anaheim, Calif. Arium, a privately held company, is responsible for 15% of all the logic analyzers sold, claims vice president David Blakemore, yet makes only 2% of the market's dollar sales. Monster instrument companies like Gould, Hewlett-Packard Co. and Tektronix are entering Arium's domain not necessarily to make money, Blakemore says, but "so they can offer a, quote, broad product line."

Charles Wiley, marketing operations manager for logic analyzers at Tektronix, the company Prime Data says owns the high end, puts it more bluntly. He admits that customers of Tek's midrange 1200 series analyzer "wanted one on each desk and had gone to our competitors" for less expensive models.

"We'd like to establish enough presence in the low end so that there is little or no reason for anybody else to try and get in," Wiley says. The "anybody else" in question is Japanese competition. "In a sense, we're taking the battle to their turf for a change."

Buying in

Tek took the first step of the battle by buying an Arium competitor, Breeze Test Instruments Inc. of Broomfield, Colo. Tek bought Breeze right out from under Gould, as Gould was reselling Breeze products under its own label. Gould is retaliating by building its own low-end logic analyzer that should be out this month, according to John Adam, marketing vice president of Gould's Design and Test Systems division in Cupertino, Calif.

Gould sold some 600 of its K20 and K40 low-end analyzers in the United States last year, Adam says, but admits that the low-priced models squeeze his margins. Arium's Blakemore says big companies that sell direct cannot afford the sales. "They can't make a sales call for $3,000," he says.

Tek bought rather than built its model because, Wiley says, Tek was previously unsuccessful trying to "hack down" a higher performance model. Tek will reposition its current low-cost model — manufactured through its joint-venture with Sony Corp. — as a ruggedized portable for the service market. Wiley also says direct sales may be too costly for the low-end market. "The key is to get other sales channels," he says.

Eastern entries

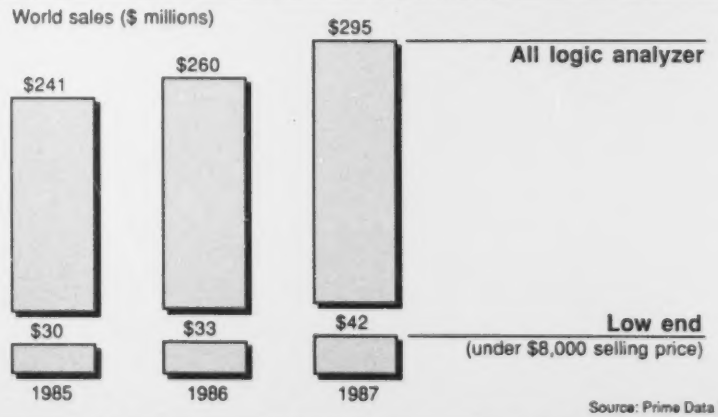
Analyst Wampler estimates that 16% of the world's logic analyzers are sold in Japan, but that they are mostly sold by Tek and Hewlett-Packard. In contrast, only 10% of all oscilloscopes are sold in Japan, but nearly all Japanese instrument companies sell scopes. He says the software-intensive logic analyzers have not attracted the Japanese instrument makers so far, but that may change.

Panasonic, for one, has stuck with its expertise in signal generators and digital scopes, says Frank Orrow, manager of Panasonic's Instrumentation Department in Secaucus, N.J. In Japan, Panasonic (a subsidiary of electronics giant Matsushita Electric Industrial Co.) builds logic analyzers only for its largest customers. Nippon Telegraph and Telephone Corp., for example, buys hundreds and distributes them across Japan, he says.

In the United States' low-end market, Panasonic sold under $2 million worth of its VP-3621P last year, Orrow says, but it was a profitable business. Panasonic "would have dropped the line if it were horrible," he says. He had to raise prices because of the strengthening of the yen versus the dollar.

Still, one reason Panasonic is sticking it out is that the low end is attractive in these times of tight equipment budgets. "Everybody is short on cash these days and is saying, 'Let's stick to what we can afford,'" Orrow says. Frugal buyers are even purchasing

Logic analyzer sales perk right along



demonstration units, he adds.

A force in the Japanese microprocessor development systems (MDS) market, Sophia Computer Systems Inc. is now in the logic analyzer business as well. Sophia is reselling the complete analyzer line of Dolch Logic Instruments GmbH. Dolch, in turn, is selling Sophia's MDSes in Europe, after shutting down its U.S. manufacturing and sales efforts.

"A lot of the strength of the analyzer market is in the low end," says Ken Pine, Sophia's sales and marketing vice president out of Santa Clara, Calif. He maintains Dolch had been doing well in the low end. Although he admits the 40C50 analyzer "is not a cash-thrower right now," he hopes to sell $3 million worth this year.

Sophia also sells its own Japan-built logic analyzer, but it is "rather simple" in technology, Pine concedes. He says Sophia considers itself more a trading company than a manufacturer. The addition of logic analyzers broadens Sophia's product line and adds revenue "to support our field crew," Pine says. Arium started to sell its own MDS last year.

Panasonic expects a shakeout in the rapidly crowding business. "In three to five years there will only be a few people in the market," Orrow says. To add to the crowd, Hewlett-Packard should be entering the low end soon from its strong position in the midrange, the contestants agree. HP says it does not talk about unannounced products.

"If it has HP's name on it, it will sell," says Arium's Blakemore. He also thinks Tek has proven itself adept at inexpensive instruments, citing Tek's recapturing of the low-end oscilloscope market from Japanese competitors five years ago. Blakemore hopes he has enough of a lead on the big guys, with volume sales to Hughes Aircraft Co. and Unisys Corp. Also, N.V. Philips Gloeilampenfabrieken sells Arium analyzers in Europe.

Right now though, most of the business is in small sales. One such small sale was at Applied Automation Research Corp., a builder of custom process controllers. Applied Automation's president, Peter Lenan, says analyzers from HP and Tek were too expensive and too hard to learn for his taste. "They must have had a ton of venture capital," Lenans says of Arium, "The amount of engineering that went into it is unreal." Blakemore can smile at such praise — Arium has no outside investors.

DAVID CARD

Can Fairchild find smooth sailing for the Clipper?

Fairchild's new 32-bit chip has been slow to gain industry acceptance. So far, it has signed up a half dozen vendors

After spending tens of millions of dollars and four years of development time, Fairchild Semiconductor Corp. shipped the first of its 32-bit microprocessor chips, known as Clipper, in early 1986. But despite superior performance and Unix availability, demand for Fairchild's 5 MIPS (millions of instructions per second) Clipper is still slow.

Rival Intel Corp., for example, began delivering its much-touted 80386 at the end of last year, only several months behind schedule. Yet, at the start of 1987, Intel's customer list for the admittedly less powerful 32-bit chip read like a who's who in high tech, including COMPAQ Computer Corp., Convergent Technologies Inc., Gold Hill Computers Inc., Sun Microsystems Inc. and Televideo Systems Inc. Fairchild, meanwhile, had signed up only one major or original equipment manufacturer (OEM) — computer-aided design (CAD) vendor Intergraph — and a handful of smaller ones — Logic Replacement Technology Ltd. (LRT), Opus Systems, Specs and Zaiaz International — to incorporate Clipper into their products.

Clipper has also failed to make significant inroads into Motorola Inc. 68020 or National Semiconductor Corp. 32032 territory. "I don't expect Clipper to have much of an impact on the next generation of microprocessors [such as the Intel 80486 and Motorola 68030)] either," says Patricia Galligan, a research analyst with Dataquest Inc. of San Jose, Calif. Of the 478,000 32-bit microprocessors shipped worldwide last year, Clipper and a handful of others together accounted for less than 6% of those shipments, Galligan claims, while No. 1 vendor Motorola amassed 47% of the 1986 shipments.

Why has Clipper been slow to gain industry acceptance? It certainly is not software. Fairchild is probably ahead of most other chip makers in encouraging companies to develop versions of their applications software which will fully use Clipper's speed and other advanced capabilities. Besides, like all of the top 32-bit chip makers, Clipper's base operating sys-

FAIRCHILD's SACHS claims that the Clipper has the highest performance of any microprocessor on the market

tem is a spin-off of Unix V, Version 3.0 — the latest and greatest release from Unix-developer AT&T. As a result, Clipper can run most of the rapidly growing base of existing Unix programs. Clipper customer Opus, for one, a vendor of IBM AT-based "personal mainframes," reports almost no difficulty in adapting software written for its National 32032-based products to its new Fairchild-based line.

"We have the highest performance microprocessor on the market today. It dissipates the least amount of power, takes up the smallest amount of space, and, from a price/performance view, is the least expensive," crows Howard Sachs, vice president and general manager for Fairchild's Advanced Microprocessor Division, the group in charge of Clipper, which is based in Palo Alto, Calif.

The club

However, the price of Clipper — $1,200 to $1,800 apiece, depending on quantity, or three or four times the average price of other 32-bit microprocessors — is not much of a factor in the chip's failure to win key designs. Also, analysts say, the established Motorola/Intel/National club is a tough one to crash, even though software compatibility across processors is less of a problem these days — thanks to Unix. Nonetheless, hardware and software design differences between new chips like Clipper and the 80386, 68020 and 32032 quickly become magnified in engineers' minds, analysts say.

"Clipper is an excellent device providing many solutions for many applications," says Dean Winkelmann, a research analyst with the Scottsdale, Ariz., market research firm Integrated Circuit Engineering (ICE). "But it is a distinctively different product — different to the point where it will be received by some people with skepticism and others with inexperience."

Besides, "the faster your product, the narrower your market becomes," says Winkelmann. "In the middle ground [where other 32-bit microprocessors end, and superminicomputers begin, in terms of price/performance] it's anybody's guess how big that niche will be. People are ready for the product, but it's a question of who will need it."

But Clipper's customers are betting that a lot of people are more than ready for the chip's super-advanced technology. Specs, a Munich-based vendor of VME boards; and LRT, another VME-board vendor based in Reading, England, are only the most recent converts.

Clipper "is opening a new page in the computing book," quips John Dodd, marketing manager for Huntsville, Alabama's Zaiaz, a vendor of advanced graphics boards for the IBM PC-AT, and one of the earliest Clipper devotees. "The introduction of Clipper is equal in importance to IBM's introduction of the PC." As opposed to other users of workstation and personal computer products that do not care whose chip is powering a system "our customers are very brand-conscious with this new generation of chips," Dodd says. "I attribute this to the fact that Clipper represents such a leap in power."

"Our customers know about Clipper," concurs Roland Schmidt, system product manager for Cupertino, California's Opus. "They're buying power and performance." Customers in the markets that Opus is targeting with its new top-of-the-line desktop workstation — large design simulation, finite element analysis and modeling, and nonturnkey CAD — "have an insatiable appetite for MIPS," Schmidt explains. "They want to do the kinds of things people do through time-sharing on a Cray [supercomputer]." Other 32-bit microprocessors just are not up to these tasks, he says.

Fujitsu in the wings

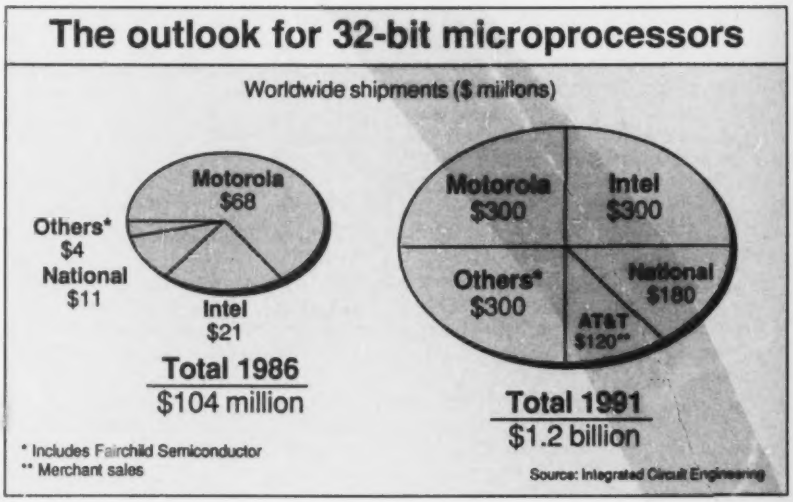
Another "customer" reported to be extremely interested in Clipper is Fujitsu Inc., which at press time was awaiting Justice Department approval of a plan to buy 80% of Fairchild Semiconductor from current parent Schlumberger Ltd. "One of the top reasons Fujitsu is looking at Fairchild may be the Clipper chip," claims ICE analyst Winkelmann. Fujitsu is in the process of designing, in conjunction with Hitachi, a 32-bit chip which reportedly will run Japan's alternative to Unix, TRON (the Tokyo Real-Time Operating System Nucleus). But that chip "addresses a different marketplace," says Fairchild's Sachs. "I don't foresee it being a source of any immediate competition or conflict."

Because of Justice Department regulations, Sachs refused any further comments on Fujitsu's current or future interest in Clipper. The company will also not talk about widespread speculation that the government may try to block the sale of Fairchild, an important military contractor.

As far as Fairchild's own future plans for Clipper, Sachs says that the chip's architecture is just at the start of its life cycle. Within five years, performance could expand from 5 MIPS to 50 MIPS, he claims. And Fairchild's recent announcement that it plans to move Clipper through the distributor channel, in addition to its direct salesforce, could also give the product a sales boost. But this will only happen, as long as rival chip makers, angry over the intended merger with Fujitsu, do not succeed in pressuring distributors not to accept any Fairchild/Fujitsu products.

But even Sachs is realistic about how much market share Clipper can expect to gain, even under the best circumstances. "Microprocessor choices are not made just on performance. They're also made on future products, existing software bases, etc. Clipper might mean a total redesign for some companies." And most are understandably unwilling to undertake such a venture, he admits.

MARY JO FOLEY



A market emerges for modem-based networks

Modem-based network management systems are a promising niche in the network control market

Network management is the communications buzzword of 1987. Every end user wants it and most communications equipment vendors claim to have it. But in a market that seems to have as many segments as players, a number of modem manufacturers have succeeded in developing a clearly defined niche within the network management arena.

The demand for modem-based network management systems — which collect test data from intelligent, microprocessor-based modems or multiplexors and display the results — is expected to grow to $137.4 million by 1990, from $104.5 million in 1986, according to Dataquest Inc., the San Jose, Calif., market research firm.

Fueling the growth of this niche, as well as the overall network management market, is the proliferation of increasingly complex private networks. According to research firm International Resource Development Inc., in Norwalk, Conn., the market for private network equipment and services, valued at $7 billion in 1985, will climb to $40 billion by 1995. This includes mammoth systems, as well as smaller modem-based operations. Electronic Data Systems Corp., the General Motors Corp. communications subsidiary, for example, has already invested some $500 million in a digital infrastructure of switches, trunks and terminals to service the needs of its parent corporation.

A survey of network management installations at more than 250 *Fortune* 1000 companies conducted by The Market Information Center reveals that today, the network management portion of communications budgets averages only 9%. That number, however, is expected to reach some 15% to 20% by the early 1990s, according to the Marlborough, Mass., research and consulting firm. More than half of the sites surveyed did not have any type of network management — 8% are in the process of evaluating systems and 43% have not yet started to investigate the implementation of any network management systems.

Of those that do have some sort of management system in place, 42% have installed modem-based management systems from the following vendors: Codex Corp., a division of Motorola Inc.; General DataComm Inc. (GDC), Paradyne Corp. and Racal-Milgo Inc., a division of Racal Electronics Ltd. Part of what makes these vendors so successful in such a fragmented marketplace is that they offer a systems, rather than a piecemeal, approach to network management and control. Up until just a few years ago, the trend in network management was based primarily on standalone diagnostic equipment that would test only minute portions of the network. Currently, however, "there is a move away from pure technology products to a whole systems approach," says Barry Gilbert, executive vice president of The Market Information Center.

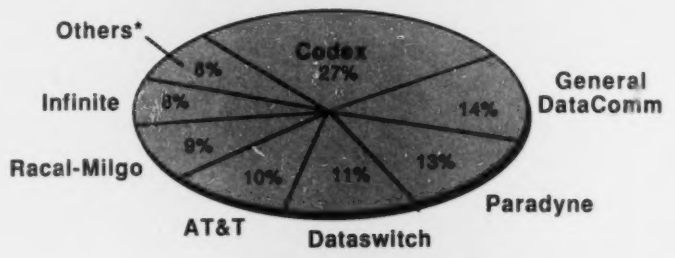
At all levels of network management, ease of use and flexibility are musts, says William Victoria, product line manager at GDC's Network Management Systems Division, based in Middlebury, Conn. Prices for systems that manage data communications

The U.S. market for data network control systems

Categories	($ millions) 1986	1990	Compounded annual growth rate
Third-party network management services	$192.0	$ 488.0	+23.6%
Protocol analyzers analog & digital	155.5	125.9	-5.1%
Network switches	165.0	170.2	+0.08%
Modem-based network management systems	104.5	137.4	+7.1%
Other	136.9	231.9	—
Total	**753.9**	**$1,113.4**	**10.3%**

Source: Dataquest Inc.

Modem-based network management systems market



Total 1986 shipments

Approximately 775 systems

*Including Digilog and Dynatech

Source: International Data Corp.

highways can start at the $20,000 range and go beyond $350,000. After such a hefty investment, Victoria says, customers want relatively inexpensive options if they need to change or upgrade their systems. GDC bases its management systems on a Unix core, but because of the software involved, a customer could also use an IBM PC AT, or a DEC VAX or PDP, at the central controls of the network, according to Victoria. "The key," he emphasizes, "is not to become hardware bound."

For personal computer-based management systems, either IBM PCs or IBM-compatibles with good graphics capabilities, are in vogue. And the Digital Equipment Corp. VAX series is the most popular minicomputer, according to Kathryn Korostoff, a research analyst at International Data Corp. (IDC) in Framingham, Mass. Of the approximately 775 modem-based systems sold last year, IDC says the majority were sold with terminals, about one-third with PCs, and no more than one-fourth with VAXs.

Because of the expense of systems and the quickening pace of technology, renting rather than purchasing equipment has become another customer option. Racal-Milgo, for example, now leases the majority of its systems, says Richard Courtney, marketing manager for network control systems at Racal-Milgo. The basic cost of a Racal-Milgo network management system can run between $10,000 and $60,000. Because network management is changing so rapidly, Courtney suggests, customers "have to take a hard look as to whether to buy or rent."

Services for sale

There is also a lucrative market emerging for third-party network management services. This segment, valued at $192 million last year, is forecast to reach $448 million by 1990, reflecting a 24% compounded annual growth rate, according to Dataquest. More than one modem management systems vendor is looking for additional revenue opportunities in this arena.

Largo, Florida-based Paradyne entered the third-party network services market last September with its announcement of NetCare Services — which provides both on-site and remote management services. According to Richard P. Checket, director of NetCare Services, Paradyne views this arena as "becoming a major portion of our business." Paradyne currently has customers in six states.

> Today there is a move away from pure technology products to a systems approach

This past January, Codex began offering its ONLINE Remote Network Monitoring Service. Although the original business plan forecasted that small- to medium-sized businesses would be the ones most ready for this type of service, a surprisingly large number of *Fortune* 500-sized potential customers are expressing interest in ONLINE, says Paul LaRiviere, director of the Advanced Implementations Group at Codex's customer services division in Mansfield, Mass.

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Where's the juice in U.S. power supplies?

With excess capacity and slow growth, power supply makers are shrinking designs and rethinking their strategies

By Bruce C.P. Rayner

With the elusive electronics recovery still just around the corner, the prognosis for the $5 billion U.S. power supply industry is for another flat year in 1987 with expectations of better health in 1988. Because the market is fragmented, strategies for survival differ. But the emphasis by many U.S. companies is on broadening product lines, reducing manufacturing costs and entering new markets.

Domestic consumption of power supplies is forecast to grow a meager 8% to $5.3 billion this year, up from $4.9 billion in 1986, forecasts Mohan Mankikar, president of Micro-Tech Consultants (MTC), a San Francisco-based market research firm specializing in the power supply industry. With too much excess capacity and over 400 companies vying for a piece of the action, it will take business acumen and a fierce competitive drive to increase market share.

A switch to converters?

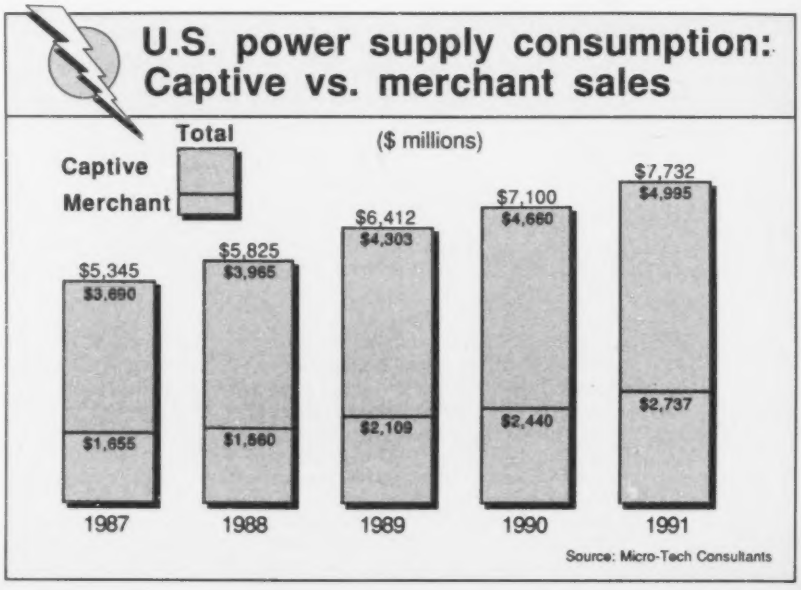
Power supplies provide the direct current that electronic circuits need to operate at a constant, regulated voltage. There are three main types of supplies: alternating current to direct current (AC/DC) with linear regulation, AC/DC with switching regulation, and DC/DC converters. Switching power supplies, or switchers — which make up almost 50% of U.S. consumption — will continue to capture the lion's share of the market, says Mankikar, growing to over 60% of total U.S. consumption by 1989.

Switchers wrestled away market leadership from linear supplies in the early 1980s as a result of the growth in the personal computer market. (Switchers can be smaller than linears of the same power rating because linears dissipate excess energy as heat, whereas switchers regulate the output voltage by switching the input on and off at high frequency.) Mankikar believes switchers will continue to enjoy the best growth potential, but expects DC/DC converters — units that take raw DC power and convert it to regulated power — to begin to gain a "higher profile" in 1987. He pegs the U.S. consumption of converters at $735 million for 1986 and expects it to grow to $1.16 billion by 1991.

Others disagree that converters, used predominantly in telecommunications equipment, will see much activity unless demand improves significantly. With telecommunications growth forecast at around 12% for 1987, Mankikar's converter expectations might prove overly optimistic, some pundits say.

But one relative newcomer in the DC/DC converter game, Vicor Inc. of Andover, Mass., is counting on converters, not only to grow, but, to radically change the power supply market in the next five years. In the future, says Vicor president Patrizio Vinciarelli, the power supply industry will be more like the semiconductor industry, demanding heavy capital investment and technology, and leaving only a few companies in positions of market leadership. This industry is about to undergo a "fairly major revolution," he predicts.

Whether or not Vinciarelli is correct will depend on more than technology. Above all, says Bruce Hamilton, vice president for marketing at ACDC Electronics, an Oceanside, California-based division of Emerson Electric Co. that makes a broad line of custom and standard supplies, the demand for power supplies follow ship-



ments of electronic components. Some forecasters expect component shipments to increase steeply by the end of the year, but, Hamilton says, "I'm not so optimistic as that."

Both the merchant and the custom market for power supplies depend on demand from original equipment manufacturers (OEMs) in the computer, telecommunications, and industrial electronics equipment industry. None of these OEM markets seem poised for much growth as equipment inventories remain high. Partly because of these excessive inventory levels, 1987 orders for power supplies are expected to grow at a slower rate than OEM production.

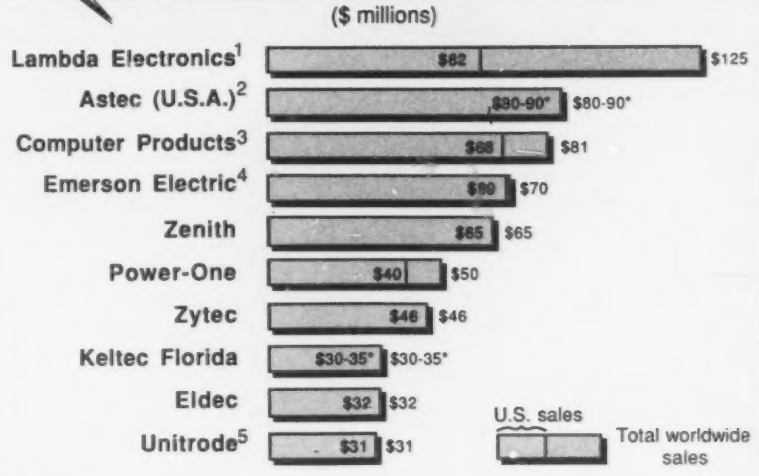
Powerful strategies

With not much overall growth expected, some of the top makers have been targeting market segments and buying into them to expand their market share. First-placed Lambda Electronics, a division of Veeco Instruments Inc., bought Magnapower Inc. in December of last year to gain entry into the military market. Previously, No. 2-ranked Computer Products Inc. (CPI) had purchased Boschert Inc., of Milpitas, Calif., a leading maker of switching supplies.

CPI president Edward Schneider does not expect the market for power supplies to recover significantly this year, but he sees his company's position strengthened by the acquisition. He says the Pompano Beach, Fla., company, which makes both custom and standard supplies at four domestic and three offshore divisions, now has a more powerful sales and distribution network. Schneider believes that the only successful way to address all markets is through multiple companies, "where you are able to market and distribute [supplies] through a single, very knowledgeable and powerful organization."

Joshua Hauser, executive vice president at Veeco's Lambda Group, says Lambda's strategy in the past has been to grow internally to meet the market demand with standard products of proprietary design. Almost 70% of the division's business is in switchers and DC/DC converters. (Mankikar estimates that Lambda sold $125 million worth of power supplies worldwide last year.) But Lambda's acquisition of Magnapower to enter the custom military market represents a break with tradition. "We look to acquisition as another way of expanding both product and market position," says Hauser.

The top 10 U.S. power supply companies in 1986



*Estimates
[1] Includes Nemic (Japan)
[2] U.S. figures only
[3] Includes Power Products, Stevens Arnold, Tecnetics, Power Products (Ireland)
[4] Includes ACDC and Rantec Power Systems
[5] Includes Power General and Powercube

Source: Micro-Tech Consultants

With pricing pressure from customers intensifying, domestic manufacturers are also looking to establish more efficient operations. Far East suppliers are able to beat domestic prices in the low-power, high-volume custom business and are starting to branch into other segments of the market as well. The way the Far East manufacturers have done that, says CPI's Schneider, is "they've successfully captured some significant business from perhaps Apple and IBM."

Lambda's Hauser believes it is the high-volume, custom-design power supply companies, both foreign and domestic, that are responsible for the severe pressure on prices. If an eager manufacturer of custom supplies signs a large-volume contract at some ridiculously low price, he says, other customers come to expect the same prices, even if they do not carry the same clout as an IBM or an Apple. As a result, Hauser says, "I don't think anybody in the custom business is making any money, they're [only] absorbing overhead." That is not the worst of it, he laments. Price wars in the high-volume business tend to spill over from the custom to the standard business. As a result, adds Hauser, domestic power supply makers must trim their sails to be price competitive.

> The pressures to keep costs down just to stay competitive are tremendous

Cutting manufacturing costs

One way to cut costs is to set up shop overseas in order to take advantage of cheaper labor and proximity to new markets. Lambda has plants in Mexico (for the U.S. market); in Israel (for Europe); and in Japan and Singapore (for the Far East). CPI is in Hong Kong, Ireland and the West Indies; Astec USA (HK) Ltd. has plants in England, Hong Kong and Malaysia; and both ACDC and Zenith Electronics Corp. have plants in Mexico. Zenith is also in Ireland.

The pressures to keep costs down just to stay competitive are tremendous, says Edgar Baez, director of marketing for the components group at Zenith, a leading producer of custom switchers for the OEM personal computer market. The Glenview, Illinois-based company last year consolidated its power supply production in a 200,000-square-foot plant in Chihuahua, Mexico, that services the United States and the Far East. It also has a plant in Kells, Ireland that caters to the European market. Zenith's strategy is to design power supplies in the United States, then set up high volume production offshore, Baez says.

As for making onshore plants more

efficient, a number of companies have adopted tighter inventory control and are automating manufacturing operations where it makes sense. ACDC's Hamilton says his company has gone to dedicated production lines and reduced inventory by adopting just-in-time (JIT) — getting components to the shop floor just in time for production. Also, comments Hamilton, "[We're] pressing our suppliers very hard to give us improved pricing."

To get component costs down, ACDC is negotiating annual purchase contracts to lower component costs. "That is a bit countercyclical to the industry," comments Hamilton, noting that many of his competitors are opting for shorter, not longer, agreements. "But to get [lower] costs," he says, "we've decided to take the risk, and it's paid off handsomely." ACDC also buys complete supplies offshore, he adds.

But Far East manufacturers can also cut costs. Astec USA, a subsidiary of BSR International Plc. of Britain, installed a computer manufacturing system two years ago in one of its Hong Kong facilities to monitor production capacity and efficiency. Astec has been "very successful" at keeping the manufacturing process under control, claims Earle Younger, marketing manager at Astec.

Tailored modules

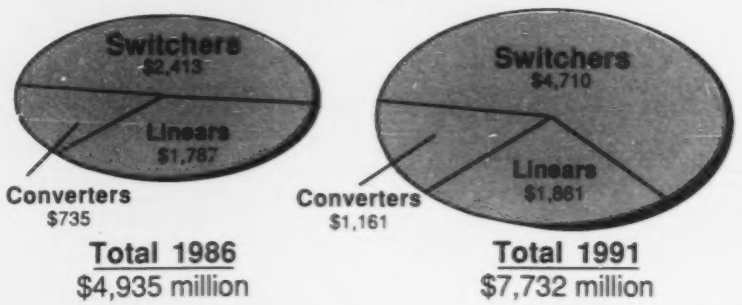
"The key to success," says Barry Chenes, vice president for marketing at Chatsworth, California-based Powertec Inc., a division of Low & Bonar Plc. from Scotland, "is to provide customers with what they want." He claims he can do this in the custom market by modifying standard products — building standard supplies to a minimum of 80% completion and then modifying them to the customer's requirements. Modified-standard supplies accounted for 60% of Powertec's $26 million sales for 1986, says Chenes. This market is fairly safe from foreign competition, he adds, because orders are relatively small in size and the producer must work very closely with the customer.

Powertec is not alone in pursuing the modified-standard approach. Hamilton claims that ACDC's dedicated production lines and the adoption of JIT allows the company to provide "modified from stock" supplies: "If we didn't have those dedicated lines and we couldn't modify those core units from inventory, we couldn't meet those [customer's] requirements." The same approach that enables faster delivery also gives reduced costs because it reduces work-in-process (WIP) inventory, he adds.

Astec, which specializes in low-power, custom switchers, employs the modular approach in its higher power (500 to 1,500 watt) lines. By using new technology available at Astec, says marketing manager Younger, the modules allow for a standard front-end with a DC voltage rail to be tailored to the customer's needs. The modular approach allows Astec to speed up the turnaround time in full custom designed switchers, Younger says.

How the pie is sliced: U.S. consumption by segment

($ millions)



Total 1986
$4,935 million

Total 1991
$7,732 million

Source: Micro-Tech Consultants

SMC for military supplies

Astec's power modules use some surface mount (SMCs) components — along with conventional through-hole components — to save space. But the cost of SMCs limit their commercial application. Hamilton of ACDC points out that the advantages of SMCs are not always evident because there is no getting around the use of bulky transformers, capacitors and inductors. "Most people won't pay for substandard sizes," he says, "and if you stay within a standard-size envelope, you can't command a premium."

But what cost constraints limit surface mount components in commercial supplies do not present a problem in the military market — a leader in the demand for miniaturization. "SM technology is advancing at the same rate as our customers' desire to have smaller, more compact and capable units," says Richard Behrens, vice president and general manager at the $32 million power conversion division of Eldec Corp., that caters to the aerospace industry.

With requirements for higher power density, Behrens says that Eldec's designers are expected to pack four watts per cubic inch. The commercial average is between one and three watts per cubic inch. The problems, notes Behrens, arise when customers want all of the extra goodies thrown in as well, like orderly start up and shutdown, and built-in test. "Nothing is getting easier," he laments.

Standard distribution

With the trend toward more standard products, makers are looking to industrial distribution as a vehicle to

U.S. switching power supply consumption by application*

	1984	1986	1989	1993
Computer	51%	50%	53%	58%
Communications	6%	6%	6%	5%
Government/military	15%	16%	15%	15%
Industrial	9%	9%	8%	6%
Business/retail	11%	11%	10%	7%
Consumer	1%	1%	0%	0%
Instrument	7%	8%	8%	8%

* Totals may not add up to 100% due to rounding

Source: Gnostic Concepts Inc.

increase market share. ACDC has signed with Time Electronics, which, together with Hamilton/Avnet, is part of Avnet Inc.'s Electronic Marketing Group; with Newark Electronics, a subsidiary of Premier Industrial Corp.; and with a number of regional distributors. Although distribution makes up only a small percentage of ACDC's sales, Hamilton says the company plans to increase its reliance on this channel. He reports good progress, for example, in distributor sales of the company's new low-power (40 watt to 220 watt) switching supplies line.

CPI's Schneider claims that the consolidation of the Boschert acquisition has given his company the strongest distribution network in the entire industry. This includes 141 North American distribution locations with the likes of Bell Industries, Schweber Electronics and Marshall Industries among others. With more than 180 distributor locations worldwide, Schneider expects CPI to outperform the market in 1987. Approximately 20% of CPI's 1986 U.S. sales and 25% of its worldwide sales were through distribution, a company spokesperson says.

But the largest manufacturer, Lambda Electronics, still believes in being its own distributor. The company has warehouses at three U.S. locations as well as in Canada, England, France, Germany, Israel, Japan and Singapore. The company has an online order entry system which, Hauser claims, allows it to deliver as quickly and efficiently as any distributor.

The trade-off between using independent distributors and in-house distribution is the cost of inventory, he explains. A customer pays either a distributor between 25% and 35% of cost, or pays the manufacturer a premium for the inventory carrying costs. After weighing these alternatives, Lambda has opted to maintain its own inventory. "If you don't have the inventory, your ability to service the customer is less," says Hauser. □

New technology from Vicor: Watts up, doc

Vicor Inc., an Andover, Mass., company that has patented direct current to direct current (DC/DC) converters, is one of a new breed of companies banking on new technology to succeed in the power supply market. Headed by a former Princeton University particle physicist, the 5-year-old company doubled its sales in 1986, from 1985, and expects to do the same in 1987. Power supply researcher Mohan Mankikar, president of Micro-Tech Consultants of San Francisco, estimates Vicor's 1986 sales at $7 million.

Patrizio Vinciarelli, president of Vicor, developed a technology for a high-frequency DC/DC converter that operates at one megahertz; 10 times faster than commercial switchers. Vicor's new converters, claims Vinciarelli, deliver 37 watts per cubic inch, more than 10 times the industry norm. Basically, there is an inverse relationship between switching frequency and a converter's size: the faster the switch, the smaller the unit.

The demand for DC/DC converters — units that convert raw DC power to rectified and regulated output voltage — is expected to increase at a compounded annual rate of 9.6% through to 1991, says Mankikar. But some types of converters, namely those that use the distributed architecture approach — placing converters directly on the circuit boards at the point of use — could outpace traditional converter demand. This calls for converters, like Vicor's, that can deliver enough power to satisfy the ever increasing number of functions and features incorporated in modern telecommunications equipment.

Vicor has two patents which have, so far, earned it over $4 million in royalties from four companies. Licensees include: Lorain Products, of Ohio, a maker of custom power supplies; Integran, a Japanese company that makes commercial units; Kollmorgen Inc., whose two facilities, Inland Motors in Arizona and Inland Power in Ennis, Ireland, supply the military and European markets respectively; and Westcor, a partially owned subsidiary of Vicor that is a second source for the domestic commercial market.

VICOR's VINCIARELLI: The power supply industry is about to undergo a "fairly major revolution"

Henry Hilliard/Picture Group

Westcor president, Allen Henderson, former director of marketing at Boschert Ltd., now a part of Computer Products Inc. (CPI), believes there is a good chance the Vicor products will become the de facto industry standard for DC/DC converters. MTC's Mankikar agrees that the potential is present. Vicor's Vinciarelli claims to have maintained that view for sometime now, "but we haven't told anyone on the outside world, except our investors," he says.

Mankikar ranks Stevens-Arnold Inc., the Boston-based DC/DC converter maker and subsidiary of CPI, as the market leader in dollar sales. But the majority of its products are under 50 watts. Vicor has targeted the 50-watt-and-above market and has managed to carve a very lucrative niche in a field with few competitors: a strategy Mankikar calls "very shrewd," adding that the company "has played its cards very well."

Vinciarelli claims that Vicor's products are not dependent on the growth in the electronics industry "because we can be very effective in displacing existing competitors." Applications for the converters range from the traditional telecommunications, computer, and industrial equipment markets to the brake system in the Japanese Bullet train and the communication system aboard Air Force One, the official plane of the president of the United States. □

The rise of Canadian electronics

Canada is the largest U.S. electronics market. But it's also becoming a major electronics exporter

By Tim Smart

In most respects, the Canadian electronics industry is a miniature version of its counterpart in the United States. U.S. firms like Control Data Corp., Litton Industries Inc., NCR Corp., Westinghouse Electric Co. and Xerox Corp. all have sizable operations in Canada. And two U.S.-owned electronics companies — IBM Canada Ltd. and Canadian General Electric, a division of General Electric Co. — had Canadian sales in 1986 of more than $1 billion each.

But Canada is also populated with such homegrown standouts, most notably telecommunications giant Northern Telecom Ltd., the country's largest electronics company, and Spar Aerospace. And while the Canadian electronics industry may never rival the United States and Japan in international prominence, it remains a leading market for U.S. computer companies and an important source of highly sophisticated telecommunications and defense electronics equipment.

The importance of the United States as a market for Canadian electronics companies cannot be understated. Of $1.35 billion in computer and office equipment exported in 1985 (the last year for which full figures are available), $1.1 billion went to the United States. Similarly, of $849 million in electrical components exported, $732 million worth went across the border.

Also, the United States sells more electronic products to Canada than any other country. In 1985, the American Electronics Association says that Canada was the recipient of $4.9 billion in U.S. electronics exports — ahead of Britain ($3.6 billion) and Japan ($3.2 billion). Canadian electronics trade with the United States in 1985 was $2.6 billion, creating a trade surplus of $2.3 billion in favor of the United States.

Although not large by international standards, the Canadian electronics industry has nevertheless shown itself to be dynamic and competitive in world markets. "Electronics is not one of the leading industries in Canada," says Christopher Trump, vice president of Spar Aerospace Ltd., a $170.89 million (for fiscal year ending Dec. 31, 1986) Ottawa manufacturer of satellites and earth stations. Forestry, mining and automobiles are Canada's largest industries, notes Trump, but, he adds, "I think increasingly there is a recognition that more needs to be done."

The U.S. sells more electronic products to Canada than any other country

Niche markets

Adds Roy Woodbridge, president of the Canadian Advanced Technology Association: "Part of the reason we lag the U.S. is really a culture and awareness problem. We still have a very strong [natural] resources-based mind-set in this country."

Nevertheless, Canadian electronics companies have carved out significant niches for themselves in several fast-growing areas of the worldwide electronics market — including telecommunications and defense-related hardware. "We're really small in consumer electronics," says Keith Munro, a specialist in U.S. trade for the Canadian government. "But telecommunications and aerospace are two industrial sectors where good things are happening."

"There's no question that our major areas of expertise are recognized worldwide," Woodbridge also notes. "But what isn't recognized is that that base of competence is fairly narrowly focused. We're going to have to rapidly diversify and broaden the base."

The semiconductor industry in Canada, for example, is very small by world standards and functions primarily as a captive supplier to the large telecommunications companies. And Canada also has about 50 printed circuit board companies, most of which produce for the export market. A third area of expertise is also very focused: the manufacture of process and inventory control systems for use in natural resource industries such as, pulp and paper and petrochemical refining.

One reason why the Canadian electronics industry has been slower to develop than its counterpart in the States is the absence of a large local market. More than three-quarters of all finished goods made in Canada are exported, and electronics goods are no

exception. Canadian Marconi Co., a leading supplier of field radios to the Pentagon, did more than half of its $165.986 million (for fiscal year ending March 31, 1986) in sales with the United States. And Northern Telecom is a major provider of central office switching equipment to the regional Bell operating companies (RBOCs).

"About 60% of our business is in the U.S.," says Andrew McMahon, executive vice president for marketing at Northern Telecom. "We've grown very rapidly in the U.S. in the last 10 years, going from roughly zero sales to where we have significant market share."

In the hotly contested market for digital switches sold to telephone companies, Northern Telecom has between 45% and 50% of the market, according to McMahon. That puts it even or slightly ahead of archrival AT&T. In private branch exchange sales, Northern Telecom has a market share of more than 20%, again competitive with the $35 billion U.S. telecom giant.

In fact, discounting Montreal-based Bell Canada Enterprises Inc., which has a controlling ownership in Northern Telecom and is not primarily an electronics company, Northern Telecom is the largest electronics company in Canada with $3.257 billion in 1986 sales.

"We're, I think, a good example of what can be accomplished by a Canadian company," says McMahon. "I think it's widely recognized that Northern Telecom has done the things that are required to be successful in the Canadian and worldwide marketplace." One thing the company has concentrated on is research and development. Bell Northern Research, in which Northern Telecom holds a majority stake, is the premier research organization in Canada.

Few government handouts

"We do not depend on government handouts or grants for any of our research or development," McMahon says, trumpeting a widely held view that the Canadian government is far less supportive of its electronics industry than is Washington. Specifically, say McMahon and others, Canadian electronics companies lack the cushion afforded their U.S. counterparts by the Pentagon, which underwrites many programs dear to the heart of the U.S. electronics industry.

"There's a virtual lack of any military research being done," says Spar's Trump. Given that, it's a wonder that

Canadian electronics exports and imports

First three quarters ($ thousands)

	1985	1986	Change
Communication equipment			
Exports	$816,772	$710,865	-13.0%
Imports	$509,953	$649,484	+27.4%
Trade balance	$306,820	$61,381	-80.0%
Electronic components			
Exports	$671,738	$626,991	-6.7%
Imports	$1,102,376	$1,076,843	-2.3%
Trade balance	-$430,638	-$449,852	NM
Telephone apparatus equipment*			
Exports	$460,612	$376,851	-18.2%
Imports	$133,445	$145,696	+9.2%
Trade balance	$327,167	$231,155	-29.3%
Printed circuit boards			
Exports	$29,402	$31,928	+8.6%
Imports	$22,355	$25,691	+14.9%
Trade balance	$7,047	$6,237	-11.5%
Computers*			
Exports	$1,011,996	$988,157	-2.4%
Imports	$2,175,788	$2,245,470	+3.2%
Trade balance	-$1,163,791	-$1,257,314	NM
Integrated circuits and semiconductors*			
Exports	$451,058	$383,845	-14.9%
Imports	$692,451	$646,036	-6.7%
Trade balance	-$241,393	-$262,191	NM
Television sets			
Exports	$36,394	$29,903	-17.8%
Imports	$111,566	$139,845	+25.3%
Trade balance	-$75,172	-$109,942	NM
Radios			
Exports	$4,112	$3,123	-24.1%
Imports	$136,539	$130,203	-4.6%
Trade balance	-$132,427	-$127,080	NM
Combination radio/phonograph sets			
Exports	$72,286	$71,486	-1.1%
Imports	$167,943	$170,855	+1.7%
Trade balance	-$95,657	-$99,369	+3.9%
Geophysical and mineral prospection equipment*			
Exports	$20,112	$28,238	+40.4%
Imports	$115,636	$69,598	-39.8%
Trade balance	-$95,525	-$41,359	-131.0%
Commercial communication equipment			
Exports	$224,708	$239,303	+6.5%
Imports	$171,151	$223,704	+30.7%
Trade balance	$53,557	$15,599	-70.9%
Photocopy machines*			
Exports	—	—	—
Imports	$162,776	$196,272	+20.6%
Trade balance	-$162,776	-$196,272	NM

* Includes parts
NM = Not meaningful
Conversion rate: Canadian $0.743 = U.S. $1

Source: Government of Canada, Regional Industrial Expansion

Canadian firms are as successful in selling to the U.S. Department of Defense as they are, something that is partly explained by policies that Ottawa and Washington have set to ensure reciprocal trade in arms.

"There's a good trade in defense electronics," says Robert Craig, a commercial counselor at the Canadian Embassy in Washington. "We had [military] sales in 1985 to the U.S. of about $1.6 billion but they're going to be down a bit in 1986. I would say of that trade, about 25% or so is in electronics."

"There is an understanding and letters of agreement that we will kind of keep the defense trade in balance," Craig adds.

Even so, the Canadian defense electronics industry has nothing to be ashamed of. Canadian Marconi, for example, has more than half of the worldwide market for VHF/UHF tactical military radios, which are made in Montreal. Garrett Canada, with headquarters near Toronto, produces more than three-quarters of all the aircraft temperature control systems in use. Other successes include the Canadian subsidiary of Litton Industries, which builds inertial navigation systems for the cruise missile, and CAE Electronics Ltd., which supplies commercial jet flight simulators to U.S. airlines.

The Canadian defense electronics industry had sales of $3.8 billion in 1985 — $1.6 billion of which went to the Canadian armed services — and was projected to have increased that to $4.4 billion by the end of last year. The industry employs more than 40,000 people in Canada.

U.S. influence

Much of the electronics business in Canada is conducted by wholly owned subsidiaries of U.S. firms, which have extensive sales and manufacturing activities north of the border. IBM Canada and GE combined, for instance, did more than $2.2 billion in sales last year and the Canadian subsidiaries of Digital Equipment Corp., Westinghouse and Xerox each had more than $372 million in sales.

The heavy amount of foreign investment in Canada's electronics industry is evident in that the leading companies are either owned outright by U.S. or British companies or their shares are widely traded on the New York, Toronto and Tokyo stock exchanges. But the subsidiary relationships go both ways. Northern Telecom and Mitel Corp., two of Canada's leading telecommunications firms, both have United States-based subsidiary operations.

The presence of a huge market across the border and the high percentage of U.S. firms in the industry has led some to doubt whether Canada can develop that large of an electronics industry of its own. Says Trump of Spar Aerospace, "We can compete successfully with some very large players and that is the kind of mind-set we need to develop more of in Canada. For too long, there's been

Top Canadian electronics companies

Company	Canadian revenue ($ thousands)	Canadian electronics revenue ($ thousands)	Canadian employees	Canadian revenue per Canadian employee
Northern Telecom	$3,257,014.8	$3,257,014.8	46,624	$69,857
IBM Canada	2,338,964.0	2,338,964.0	11,000	212,633
Canadian General Electric	1,109,819.1	NA	11,605	NA
Xerox Canada	642,620.7	285,295.7	4,200	67,928
Westinghouse Canada	530,962.7	NA	5,400	NA
Digital Equipment of Canada	466,898.7	466,898.7	2,598	179,715
3M Canada	319,490.0	31,949.0	2,000	159,745
Mitel	302,428.7	302,428.7	4,655	64,969
Rogers Communications	302,096.8	302,096.8	3,350	90,178
ITT Canada	289,027.0	NA	5,000	57,805
Honeywell [1]	284,790.4	284,790.4	3,781	75,321
The Philips Group	266,977.0	18,906.8	1,830	10,332
CAE Industries	243,704.0	110,239.2	4,800	22,967
Sperry [3]	231,816.0	231,816.0	NA	NA
Litton Systems Canada	227,052.0	227,052.0	3,300	68,804
Matsushita Electric of Canada [2]	222,900.0	222,900.0	NA	NA
Control Data Canada	215,406.6	215,406.6	1,800	119,670
Hewlett-Packard (Canada)	209,633.0	209,633.0	1,136	184,536
Burroughs [3]	167,175.0	167,175.0	NA	NA
Canadian Marconi	165,986.1	154,279.2	2,400	64,283
NCR Canada	155,400.0	139,860.0	2,050	68,224

[1] Company estimate
[2] ELECTRONIC BUSINESS estimate
[3] Now Unisys Corp., formed by the merger of Burroughs and Sperry in September 1986; Canadian merger effective January 1987

kind of a 'branch plant' mentality here."

Martin Robichard, a trade officer in the Canadian consul's office in Boston, says Canadian firms have not been aggressive marketers of their country's products. "They have the European style of laid-back marketing," Robichard says.

One immediate problem for Canadian exports to the United States could be the weak dollar, which is making goods produced in other countries more expensive for U.S. customers. Jeanette Garrety, a Bank of America economist and specialist in the electronics industry, says that during the next decade U.S. companies will see their exports increase 50%. Presumably this would be at the expense of exports to the United States, but Garrety says it is uncertain what effect this will have on Canada, where the dollar-to-dollar relationship has not changed that much.

"The U.S. dollar has not fallen as dramatically against the Canadian dollar as it has against the Japanese yen or the German mark," Garrety says. There is also the question of the overall trade relationship with Canada during this time of pro-protectionist feelings in the U.S. Congress.

The industry in Canada is supported by a network of universities, investment banks, venture capitalists and trade organizations. More than 100 companies belong to the Canadian Advanced Technology Association, which assists in the promotion of Canadian-owned technology companies. Membership is across a broad spectrum, though many are small, closely held ventures. The membership rolls do include such Canadian electronics industry giants as Electrohome Ltd., makers of video display equipment, and Mitel Corp.

"They're research-intensive companies," says Woodbridge of the Advanced Technology Association. "The members are primarily from information technology fields but we have branched out far beyond that to biotechnology and advanced materials."

In doing so, the association reflects the unique nature of the Canadian economy. Unlike the United States, where start-ups are often clustered around technologies spawned by the electronics industry — like personal computers and video equipment, many of the newer Canadian firms are allied to the bedrock natural resource-based industries. HSA Reactors Ltd., a Rexdale, Ontario company, for instance, makes computer-based systems used in the recovery of mined metals. Mechron Energy Ltd. manufactures electric power systems for use in harsh environments. More than 75% of all electronic equipment used to detect minerals is manufactured in Canada.

Of the venture capital industry in Canada, Woodbridge says: "It's not quite as vigorous as it is in the U.S. We have lagged in comparison, particularly with regard to investment in start-ups, but it is extremely active and growing." □

Parent company	Parent company revenue ($ thousands)	Total employees	Overall revenue per employee	Canadian revenue as a percent of parent company revenue	Canadian electronics revenue as a percent of total Canadian revenue	Fiscal year end
Bell Canada Enterprises	$13,932,500.0	109,592	$127,131	23.4%	100.0%	12/31/86
IBM	51,250,000.0	403,500	127,014	4.6%	100.0%	12/31/86
General Electric	35,210,000.0	359,000	98,078	3.2%	NA	12/31/86
Xerox	12,900,000.0	100,367	128,528	5.0%	44.4%	12/31/86
Westinghouse Electric	10,731,000.0	115,000	93,313	4.9%	NA	12/31/86
DEC	7,590,357.0	94,700	80,152	6.2%	100.0%	6/28/86
3M	8,602,000.0	33,800	254,497	3.7%	10.0%	12/31/86
British Telecommunications	8,387,000.0	NA	NA	3.6%	100.0%	3/28/86
Rogers Communications	411,016.0	3,350	122,691	73.5%	100.0%	8/31/86
ITT	17,500,000.0	120,000	145,833	NA	NA	12/31/86
Honeywell	5,328,000.0	77,000	69,195	5.3%	100.0%	12/31/86
N.V. Philips	6,004,500.0	345,600	17,374	4.4%	7.1%	12/31/86
CAE Industries	332,929.0	5,160	64,521	73.2%	45.2%	3/31/86
Unisys	7,400,000.0	NA	NA	3.1%	100.0%	12/31/86
Litton Industries	4,521,000.0	55,000	82,200	5.0%	100.0%	7/31/86
Matsushita Electric of America	NA	NA	NA	NA	100.0%	12/31/86
Control Data	3,350,000.0	34,000	98,529	6.4%	100.0%	11/30/86
Hewlett-Packard	7,100,000.0	82,000	86,585	3.0%	100.0%	10/31/86
Unisys	7,400,000.0	NA	NA	2.3%	100.0%	12/31/86
Canadian Marconi	226,634.0	2,500	90,654	73.2%	92.9%	3/31/86
NCR	4,881,641.0	62,000	78,736	3.2%	90.0%	11/30/86

Source: ELECTRONIC BUSINESS

U.S. versus Japan in the year of the high yen

Comparing operating costs of Japanese electronics firms with those of the U.S., Japan once again fares well

By Paula Doe

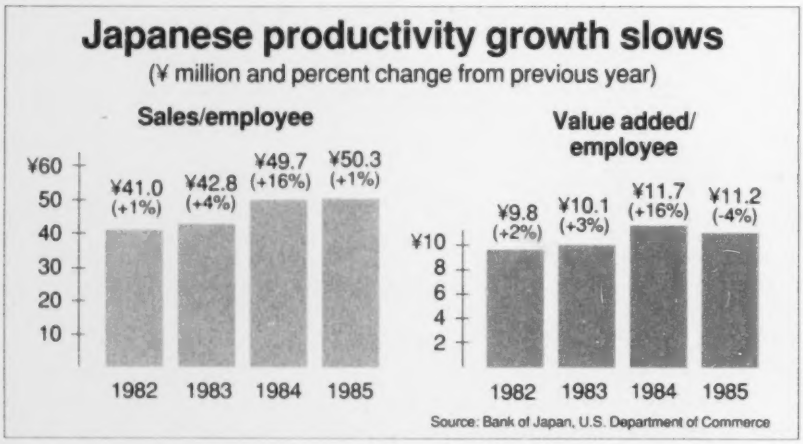
It was not a great year by any means, but the Japanese electronics sector as a whole did much better than some other segments of the Japanese economy. Nevertheless, Japan continued to outperform their U.S. high-tech counterparts in several key areas — including sales per employee, income per employee, and five-year compounded sales growth. And as usual, American firms outperformed the Japanese based on criteria which are usually associated with shorter-term gains — earnings, return on investment and return on equity.

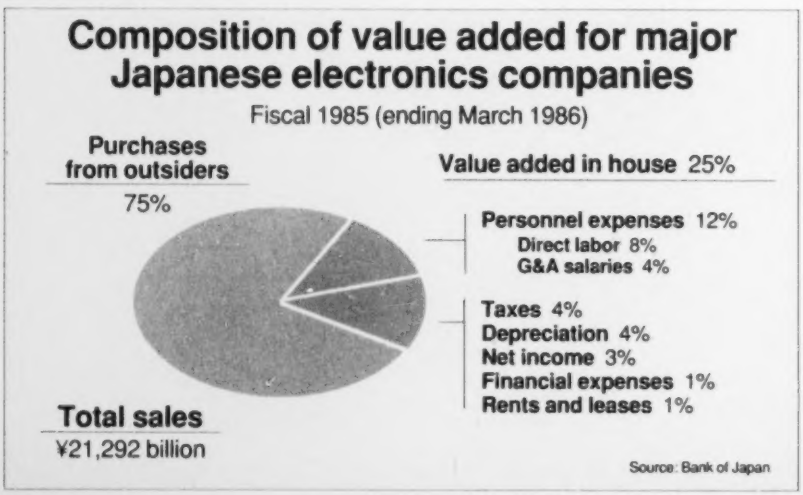
Our analysis is based on data derived from company documents published by the top 20 electronics companies in the United States for fiscal 1985. We compared this information with data supplied by a recent report by the Bank of Japan. The bank's report, which analyzes the operating costs of 29 Japanese electronics companies in fiscal 1985 (for the period ended March 1986), also indicates that the Japanese electronics sector as a whole did better than most of the larger companies in Japan which rely heavily on exports. Also, during a period when the value of the yen rose about 30% in relationship to the dollar, the electronics sector, by and large, has reacted quickly to cut costs by finding cheaper outside sources of supply. But the industry still faces an eroding manufacturing base, excess domestic workers and sagging productivity.

The Bank of Japan study, which is obtained and translated each year by ELECTRONIC BUSINESS, provides a remarkable portrait of the cost of doing business in Japan. Compiled annually by the bank's research department, it offers extensive, and frequently exclusive, financial information from representative companies in Japan's computer and electronics sector on estimated operating costs. In this article and its accompanying charts, ELECTRONIC BUSINESS analyzes the bank's statistics, and compares them with those from our own database of the leading U.S. electronics companies.

Although the bank does not actually disclose which Japanese companies it talked to, ELECTRONIC BUSINESS is in a position to make some educated guesses — since most of the companies are publicly listed with capital of at least $5.5 million or ¥1 billion, based on a currency translation of ¥180=$1.

The general producers of electrical and electronic equipment — indicated in the main charts accompanying this article are Fuji Electric Company Ltd., Hitachi Ltd., Mitsubishi Electric Corp. and Toshiba Corp. The consumer electronics companies presumably include Fujitsu General Corp., Matsushita Electric Industrial Company Ltd., Matsushita-Kotobuki





Selected comparisons of financial data of Japanese and U.S. electronics companies

Data for fiscal 1985 (¥180 = $1)

			Japanese sectors			
	Top 20 U.S.-based electronics companies	Top Japanese electronics companies	General electrical and electronic equipment	Consumer electrical and electronic equipment	Telecommunication and other electronic equipment (including computers)	Electronic components
Total sales ($ millions)	$123,895	$118,291	$42,945	$43,768	$24,038	$7,540
Operating costs as a percentage of sales						
Cost of goods sold	48.2%	76.8%	78.8%	81.2%	69.4%	75.2%
Gross sales margin	51.8%	23.2%	21.2%	18.8%	30.6%	24.8%
Selling, G&A expense	25.8%	17.8%	17.8%	15.5%	25.3%	13.7%
Operating income	18.8%	5.4%	3.4%	3.3%	5.3%	11.1%
Pretax income	12.3%	6.7%	3.7%	6.1%	4.4%	12.7%
Net income	7.0%	3.5%	2.2%	2.9%	2.6%	6.4%
Dividends paid	3.0%	0.9%	0.8%	0.7%	0.8%	1.4%
Dividends as a percentage of net income	42.3%	26.7%	37.8%	23.6%	29.3%	22.3%
Productivity						
Sales per employee	$88,700	$267,100	$204,700	$343,600	$212,800	$219,200
Pretax income per employee	$10,900	$17,800	$7,500	$21,100	$9,500	$27,700
Returns						
Return on equity	13.2%	9.0%	9.7%	8.4%	8.9%	9.7%
Return on investment	10.6%	6.4%	5.9%	6.6%	4.7%	8.1%
Capital outlay/ net cash flow after dividends	104.4%	85%	108%	77%	101%	66%
Capital outlays as a percentage of sales	10.6%	5.6%	6.6%	3.8%	7.2%	6.5%
Five-year compounded sales growth	+11.0%	+12.3%	+9.2%	+10.6%	+16.9%	NA
Debt to capital	19.5%	25.8%	36.2%	17.7%	44.5%	13.1%
Total liabilities to equity	0.75%	1.4%	2.74%	1.04%	2.15%	0.47%
Current assets to current liabilities	2.18	1.70	1.19	1.41	1.42	3.02
Exports as a percentage of sales	34.4%*	39.3%	29.5%	50.3%	28.2%	36.3%

* Includes exports plus foreign operations

Source: Bank of Japan, ELECTRONIC BUSINESS

Electronics Industries Ltd., Pioneer Electronic Corp., Sanyo Electric Company Ltd., Sharp Corp., Sony Corp. and Victor Company of Japan Company Ltd. The makers of telecommunication and other electronic equipment presumably include Fujitsu Ltd., NEC Corp. and Oki Electric Industry Company Ltd. Component producers presumably include Alps Electric Company Ltd., Kyocera Corp. and TDK Electronics.

A balanced economy

Sales overall, the report indicates, were up about 3% in yen for fiscal 1985 (year ended March 1986) for the 29 representative electronics companies analyzed by the bank. Strong domestic demand for telecommunication and office automation equipment helped balance out poor results in semiconductors and exports. Earnings were off an average of about 15%. That is a far cry from the widely publicized 56% drop in earnings at Fujitsu Ltd. and 29% slump at Hitachi Ltd.

The Japanese companies' gross sales margins were down an average of 5%. Manufacturing costs climbed 3%, as overhead and labor expenses crept up. Selling, general and administrative expenses also went up about 7%, due to increases in salaries, advertising and miscellaneous expenses. Exports were down only 2%, as produc-

ers sacrificed margins to avoid raising prices.

This all adds up to a sobering 35% average drop in operating income. But many Japanese companies are loaded with cash from past fat years, and earned enough on their investments to counter lower operating earnings. The wealthy consumer electronics companies in fact got 3% of their total revenue from investment income — just about as much as they earned from operations. Overall, these healthy investment earnings meant net income for the sector as a whole slipped only from 4.2% to 3.5% of sales.

These figures are for the year ending in March 1986, when Japanese companies only had the high yen half of the year. But already the start of some structural changes is evident.

Most notable is the quick move to buy more outside from lower-cost producers. With some 75% of total revenue at the average Japanese electronics company already going to purchase goods and services from outsiders, these outside purchases were the quickest and easiest place for most companies to start cutting costs. In the first year of the high yen, the typical company bought 5% more outside. That pushed its own in-house added value down a corresponding 5%.

These figures are slightly misleading because they are for the parent company only, and therefore count purchases from subsidiaries as outside purchases. Still, they suggest how very significant this secondary layer of subsidiaries, affiliates, subcontractors and suppliers is to the major Japanese electronics companies. These smaller companies will be the ones that ultimately bear the brunt of the high yen. And any realistic comparison of Japanese and U.S. costs needs to take into account the much lower wage and overhead costs of these smaller companies.

Fewer administrators

The legendary Japanese productivity slipped badly in the first year of the high yen. The rush to source more components outside and offshore left the big Japanese electronics producers with excess workers. And falling prices meant that each worker had to churn out more units to achieve the same value of output. Revenue per employee was up about 1% (in yen) from the year before. But value added per employee fell 7%. And since personnel expenses rose 4%, value added

Japanese electronics sector's operating costs

Operating costs for fiscal 1985 (¥180 = $1)

	General electrical and electronic equipment	Consumer electrical and electronic equipment	Telecommunication and other electronic equipment (including computers)	Electronic components	Total and weighted average
Total sales ($ millions)	$42,945	$43,768	$24,038	$7,540	$118,291
Operating costs as a percentage of sales					
Cost of goods sold	78.8%	81.2%	69.4%	75.2%	76.8%
Cost of goods purchased	5.0%	36.3%	12.6%	23.7%	23.7%
Cost of manufacturing	71.2%	43.2%	58.2%	53.7%	55.5%
Material cost	42.4%	33.8%	39.2%	29.4%	37.9%
Labor cost	12.9%	5.1%	8.2%	8.6%	7.8%
Overhead	15.9%	4.3%	10.8%	15.7%	9.8%
Change in inventory	1.6%	1.7%	0.1%	0.5%	1.1%
Taxes	1.0%	0.1%	-0.3%	0.1%	0.0%
Other	0.0%	1.5%	-1.2%	-2.8%	-3.5%
Gross sales margin	21.2%	18.8%	30.6%	24.8%	23.2%
Selling, G&A expense	17.8%	15.5%	25.3%	13.7%	17.8%
Salaries and benefits	2.9%	3.2%	4.7%	3.8%	3.6%
Depreciation	0.2%	0.4%	0.9%	0.6%	0.5%
Taxes	0.5%	0.9%	0.6%	1.5%	0.9%
Leases	0.4%	0.4%	0.5%	0.5%	0.4%
Sales fees and commissions	0.4%	0.6%	2.1%	0.3%	0.9%
Advertising and promotion	0.9%	1.4%	1.1%	1.3%	1.2%
Shipping	2.0%	1.1%	2.3%	1.6%	1.6%
Other	10.5%	7.5%	13.1%	4.1%	8.7%
Operating income	3.4%	3.3%	5.3%	11.1%	5.4%

Source: Bank of Japan

Japanese electronics sector's value added

Value added data for fiscal 1985 (¥180 = $1)

	General electrical and electronic equipment	Consumer electrical and electronic equipment	Telecommunication and other electronic equipment (including computers)	Electronic components	Total and weighted average
Value added					
Value added per employee	$54,200	$67,200	$57,100	$72,400	$64,000
Personnel expense per employee	$32,200	$28,800	$29,900	$27,600	$29,300
Value added per dollar personnel expense	1.68	2.34	1.91	2.62	2.20
Breakdown of value added (as a percentage of value added)					
Net income	8.3%	14.8%	9.5%	19.7%	13.7%
Personnel expense	59.5%	43.0%	52.5%	38.5%	46.6%
G&A, salaries	10.9%	16.2%	17.4%	11.3%	6.9%
Manufacturing, labor	48.5%	26.6%	35.0%	26.9%	14.8%
Financial expense	5.4%	4.8%	7.4%	2.1%	5.0%
Leases	1.4%	1.9%	1.8%	1.4%	1.7%
Taxes	7.5%	21.6%	9.2%	23.5%	17.0%
Depreciation	17.9%	13.9%	19.6%	14.7%	16.0%
Value added	100.0%	100.0%	100.0%	100.0%	100.0%
Breakdown of expenses (as a percentage of sales)					
Personnel expense	15.8%	8.4%	14.1%	12.7%	11.7%
Financial expense	1.4%	0.9%	2.0%	0.7%	1.2%
Depreciation	4.7%	2.7%	5.3%	4.9%	4.1%
Variable costs	54.0%	72.9%	50.8%	59.0%	62.1%
Fixed costs	42.3%	20.9%	44.8%	28.3%	31.2%
Break-even point	92.0%	77.2%	91.0%	68.9%	80.9%

Source: Bank of Japan

Notes on tables

The Bank of Japan selects the major companies it considers representative of each sector for its annual financial analysis of the Japanese industry. Primarily these are publicly listed companies with capitalization of $5.5 million, or ¥1 billion, or more. The bank does not identify the companies individually, but the major members of each category are fairly clear. All figures are for parent company only.

COMPANY CATEGORIES

The general producers of electrical and electronic equipment are Fuji Electric Company Ltd., Hitachi Ltd., Mitsubishi Electric Corp. and Toshiba Corp.

The consumer electronics companies presumably include Fujitsu General Corp., Matsushita Electric Industrial Company Ltd., Matsushita-Kotobuki Electronics Industries Ltd., Pioneer Electronic Corp., Sharp Corp., Sony Corp., Sanyo Electric Company Ltd. and Victor Company of Japan Company Ltd.

The makers of telecommunication and other electronic equipment presumably include Fujitsu Ltd; NEC Corp. and Oki Electric Industry Company Ltd.

Component producers presumably include Alps Electric Company Ltd., Kyocera Corp. and TDK Electronics.

FINANCIAL CATEGORIES

Manufacturing overhead includes power, depreciation, leases, property taxes, maintenance and outside processing.

Number of employees is the average for the year and does not include temporary workers.

Capital outlays are the increases in property, plant and equipment, less depreciation.

Debt/total capital is long-term debt/long-term debt plus equity.

Personnel expenses include all wages and salaries, health and welfare benefits, severance pay, pensions and bonuses.

Break-even point as a percentage of sales is (fixed costs/[1 - (variable costs/sales)])/sales.

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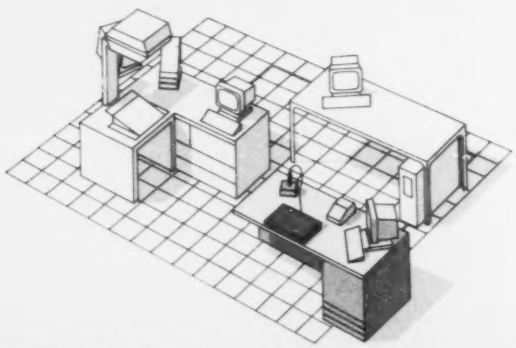

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per dollar personnel expense was off nearly 10%.

Even with the high yen, the Japanese still maintain an advantage in personnel costs. Production labor costs are still a little lower. But more significantly, they spend far less on multiple levels of management. The U.S. Department of Commerce figures a production worker cost a U.S. electronics company $13.20 an hour in 1985, compared with $5.25 an hour for a Japanese electronics company, at the average exchange rate for that year of ¥238.5=$1. At the March 1985 rate of ¥180=$1, that is $6.96. Even at ¥150=$1, the Japanese rate is still only $8.35.

At $13.20 an hour, compensation for a U.S. electronics worker for a year of regular 40-hour weeks comes to

The legendary Japanese productivity slipped badly in the first year of the high yen

some $27,500 a year. The major Japanese electronics companies averaged personnel expenses (including benefits) of only $29,300 per employee at ¥180=$1 for both management and labor.

Since production labor accounts for only perhaps 2% of total production costs, far more significant Japanese savings may come from fewer, lower paid administrators. At the major Japanese companies, 8 cents of every dollar of revenue goes to pay people involved in making things (including plant management), but only 4 cents goes to pay all other employees.

In part this is because the Japanese save on marketing expenses by selling much of their equipment on an original equipment manufacturing (OEM) basis to resellers, instead of having to maintain their own salesforces. But they also seem to have simplified their systems to reduce their overhead. Even though the typical ratio of indirect to direct labor in U.S. industry is 1:1 or 2:1, for Japanese companies it is closer to 1:2, according to Michael McGrath, a consultant with Pittiglio, Rabin, Todd & McGrath.

"We do things multiple times," explains McGrath. "We have someone place an order with a vendor every month, and then call two weeks later to check on it. The Japanese just tell the vendor to send 100 a week. They've simplified things." □

Smart power: Micro mix makes a macro market

The promise of smart power has outpaced the reality. But the equation is changing as the market finally powers up

By Mike Leibowitz

Smart power semiconductors received a tremendous amount of promotion from vendors during 1986. A projected flood of components, which marry logic control with power switching, promised to revolutionize the design of electronic equipment in only a few years. This prospect began to excite consumer, office, and industrial equipment manufacturers almost as much as it excited component manufacturers which had targeted smart power as a burgeoning product area. But the flood is now overdue.

"It's not going to happen as quickly as people projected," says Roger Janikowski, smart power marketing manager for Motorola Inc. Larry Smart, general manager of General Electric Co.'s Integrated Power Semiconductor Department explains, "Everybody grossly underestimated how much technology and work had to be addressed to get this market up."

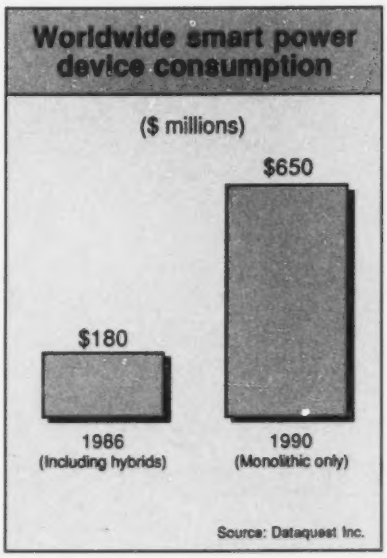
Potential users view smart power's slow progress from two distinct perspectives: For some it is a time to sit back and wait for the market to mature; for others, it is a period to leapfrog their competition with an emerging technology.

But at this early stage one prediction is certain. Many products are destined to be revolutionized by smart power. The big question is how soon.

THE MARKET

Smart power covers a very broad range of components, varying in power-switching capability from one to 1,000 watts, and containing as many as 400 equivalent gates of logic circuitry.

The applications for smart power include printers, copiers, disk drives, consumer appliances, industrial control products, telecommunication equipment, flat panel displays, power supplies, automobiles — virtually any product that includes a power device.



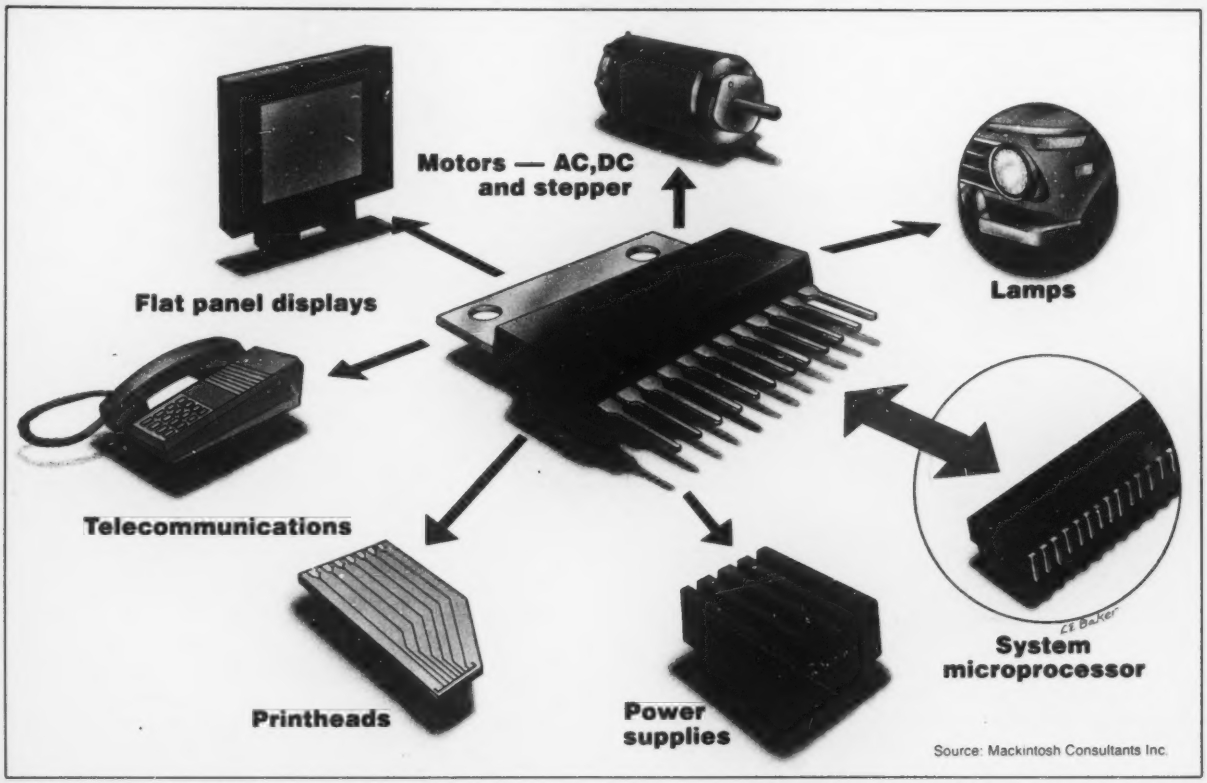
Smart power's chief benefits are in reducing system cost and size, but other benefits may also result, such as reduced power consumption, increased system reliability, and new system features. What smart power does depends on the amount of logic that is incorporated into the device.

For example, by including simple logic in a power device, a single component can switch a load such as a solenoid, motor or incandescent lamp and recognize if there is an open circuit, providing this diagnosis to a microprocessor. If there is a short circuit or the component overheats, it will recognize this also and shut down, protecting the power supply and the smart power component from damage. This fault detection and protection makes service quicker and less expensive.

By increasing the logic in a power device, the part can assume all the intelligence necessary to control a stepper motor or vary the speed of a DC or AC motor, depending on load and other criteria. A single smart power motor-control component is all that is needed between the microprocessor and a motor. It could replace up to 50 discrete components, resulting in a cost savings at the system level and allowing a product to shrink in size or add features. It could also reduce a product's power consumption.

By putting a substantial amount of logic on the power component, a whole new class of applications opens up, such as the multiplexing of automobiles, large consumer appliances and industrial process control systems. A multiplexed automobile would distribute the logic necessary to control headlights, motors, solenoids and relays by putting smart power devices at each power load. The automobile's central microprocessor would send instructions to the devices and receive status information over a single logic wire that circles the automobile. The scheme replaces an expensive and heavy wiring harness, while providing failure protection and service diagnostics.

There are approximately 40 vendors of smart power devices supplying a worldwide market projected to grow from an estimated $180 million in 1986 to $650 million in 1991, according to Ron Bohn, analyst for market research firm Dataquest Inc., San Jose, Calif. Although Bohn projects the market to more than triple during the next five years, he is very hesitant



SMART POWER COMPONENTS contain all of the logic and power circuitry necessary to control a wide variety of power loads, receive commands and return status to the system's main processor

to speculate what is going to happen in the next year or two. "There is uncertainty over whether the market is taking off," says Bohn.

Two key factors are restraining smart power's takeoff: First, advances in technology are slower than expected; and second, equipment manufacturers are hesitant to make the production commitments necessary to drive those advances. Bohn calls this "a high-tech version of the 'chicken or the egg' puzzle." Which comes first — the vendor's technology or the equipment manufacturer's applications?

In trying to project how fast smart power will advance, most eyes turn to the technology's single largest projected customer: the automotive market. "There's a lot of belief now that automotive will be the driving force," says Bohn. Some, such as GE's Smart, project that automobiles will comprise roughly 50% of the eventual smart power market.

But automobile manufacturers are moving cautiously. "We have to be very careful in automotive that we don't go too far too fast," says Gene West, supervisor of advanced computer development at the Delco Electronics division of General Motors Corp. He says that the technology must be wrung out for cost savings and reliability. Delco does have a smart power device operating in 1986 automobiles.

Lon Baker

But, says West, "As I look over the state of smart power, I don't think it is very far advanced at this stage. It's not quite there yet, from my perspective, to just say pour it in all over the place. Once we have a level of success — that's when things will really take off."

The uncertainty over how fast smart power technology will advance certainly has not held back some equipment manufacturers. Trane Co., a division of American Standard Inc., is developing a residential heat pump system, containing GE smart power components, that consumes 25% to 30% less power than equivalent systems and offers unique comfort features. One portion of the system, an air handler, is already in production. "The payoff is fantastic," says Louis Chaump, Trane's vice president for engineering. "We're already seeing a payoff."

> The worldwide smart power market is projected to reach $650 million in 1991

Trane is now well-positioned to fend off an expected influx of Japanese competition, says Chaump, but he acknowledges that they were pushing technology when they first approached vendors eight years ago. "It wasn't like we came along and cherry-picked it. It was a lot of skunk work. We invented technology."

Although a few standard smart power products have hit the market, custom designs dominate. Standard products being delivered include smart switches, motor controllers, display drivers, telecommunication switches and line-interface circuits. This is expected to grow. Says General Electric's Smart: "Those products that are custom today will become generic-standard industry products in automotive, EDP, and telecommunications." He projects that when the technology matures, standard products will make up 80% to 90% of the market. But, at least for the next few years, many expect that custom work will continue to be the major part of smart power and the driving force behind its advances.

COST OF ENTRY

The four reasons equipment manufacturers will go to smart power are "cost, cost, cost and performance," says Derek Lidow, executive vice president of International Rectifier. Lower system costs may indeed turn out to be a principal reason, but getting smart power into the end product ini-

THE TECHNOLOGY

Combining logic and power

Designing, fabricating and packaging smart power chips at a practical cost is a trick for chip makers. The difficulty is in combining high-voltage, high-current switching structures with logic at a price customers are willing to pay.

Today, vendors offer monolithic smart power chips capable of controlling a single load up to 100 volts and 10 to 20 amperes. Monolithic chips can switch multiple loads up to 300 volts and 300 milliamperes; or switch loads up to 150 volts and 1.5 amperes. As the various techniques are refined, vendors will undoubtedly reach greater voltage and current limits, and costs will go down for products at today's limits.

Is smart power monolithic or hybrid? Many disagree. A number of manufacturers offer hybrid solutions for high-power and logic-intensive applications that would be too expensive to implement monolithically — and call it smart power. They argue that smart power defines a function at the package level. Others say no; monolithics are the force behind smart power — this is the technology that will ultimately produce the greatest savings.

Just about everyone agrees, however, that hybrids will always be a used at the very high end of smart power technology, beyond the capabilities of monolithics. According to Derek Lidow, International Rectifier Corp.'s vice president for marketing, there are "a limited number of things you will want to integrate on a monolithic chip," namely, circuitry that is directly related to the power function. Lidow projects that complex logic such as a 16-bit microprocessor could never be efficiently integrated into a smart power chip; the microprocessor would run too hot and the power circuitry would run too cool to make such a device practical. "Here, hybrids will make sense," says Lidow.

Bill Numann, Siliconix's power IC marketing manager points out that as power level goes up, the power section consumes a greater portion of the chip area. Instead of putting a substantial amount of silicon through the numerous processing steps required for just a small area of logic it would be cheaper to separate it out. "Why complicate a major part of your chip?" asks Numann.

> Hybrids will always be used at the very high-end of smart power, beyond the capabilities of monolithics

Vendors of monolithic devices are pursuing a number of routes in the race to boost power capability and lower costs. Mixed technologies dominate today, offering the best characteristics of two IC technologies on a single chip. There are three types of mixed technologies: BiMOS, integrating a bipolar power section with CMOS logic; DMOS/CMOS, combining a DMOS vertical power structure with CMOS logic; and CMOS/DMOS, joining a lateral power structure in DMOS with CMOS logic.

BiMOS, developed in 1978, was the first mixed technology and is presently used at the low end: medium-speed, low-current levels of application up to 100 volts.

DMOS/CMOS and CMOS/DMOS are the newest mixed technologies and the ones expected to have the greatest growth. DMOS/CMOS, with its vertical power structure, draws current vertically to the substrate of the die, allowing it to handle a greater amount of current while consuming very little silicon for voltages less than 400 volts. The drawback is that a vertical structure allows only one switch to be integrated on a chip, prohibiting it from multichannel applications.

The lateral structure of CMOS/DMOS uses conventional linear IC technology to integrate medium-current switches onto a single chip. It consumes a great deal of silicon and is only practical for low-current, high-voltage applications but since it allows multiple switches on the same chip, it is the solution for multichannel smart power applications.

Bipolar, expected to continue losing ground to mixed technologies, was the first smart power technology, dating back some 12 years. Bipolar combines I^2L logic, linear circuits and power PNP transistors. Today, bipolar competes with the other technologies primarily in the high-voltage, multichannel, logic-intensive area.

tially is likely to be expensive.

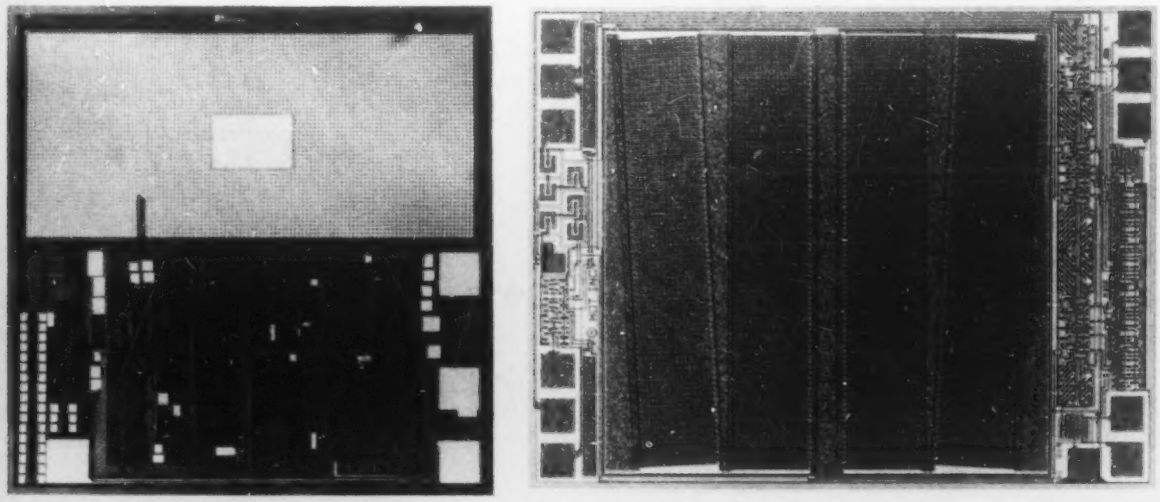
Finding a standard product to fit a particular application will require some luck. There are few standard smart power devices on the market, such as smart switches, power motor controllers, telecommunication circuits and display drivers.

For a custom design, the cost depends on a number of factors. One is complexity. Designs that push technology can send design costs soaring and result in a low-yield, high-price chip.

For high-power, logic-intensive designs, a hybrid may be the cheaper smart power device. It will certainly result in much lower design costs. According to Derek Lidow, International Rectifier's executive vice president for marketing, custom hybrid design costs range from $3,000 to $30,000, compared with $500,000 for a monolithic design. Lidow, whose company does both monolithic and hybrid designs says that it takes between six and 10 weeks for hybrid prototypes and up to 20 months for the first prototype of a monolithic design.

Motorola's Janikowski pegs typical custom monolithic design costs at between $100,000 and $180,000 for a proprietary design. Before taking on a design they look at other strategic factors, such as the likely dollar value of the program, possible sales impact on other products, how successful they will be in the first prototype, and what they might learn from designing and manufacturing the chip.

At Silconix, William Numann, marketing manager for power integrated circuits (ICs), says that a monolithic design can cost as little as $80,000, if it can be built with an available process, or as much as $300,000 if it must be built with chips requiring new process development. They look for a



MOTOROLA's MPC1500, (left) 35 volt, 16 ampere High Side Switch. Its vertical power section occupies 50% of die. Overall chip measures 170 × 170 mils. **The MPC1710** (right) H-Bridge Motor Controller utilizes a lateral power section. Eighty percent of the die is power circuitry. It measures 100 × 130 mils.

How well vendors can isolate power sections from logic determines, to a great extent, the power-handling capability of the chip. Chip makers use three main isolation techniques to separate power structure from logic. Junction isolation is the most common, and relies on a reverse-biased PN junction to achieve moderate isolation. It is an expensive method at high voltages because thick epitaxial layers and considerable silicon are necessary. At above 100 volts, techniques must be used to reduce surface field effects that disrupt the logic. Junction isolation's advantage is that it allows great flexibility in the design of the power circuit.

Self-isolation, which reverse biases the junctions of the other components, is less expensive due to the elimination of the epitaxial layer but is limited in the amount of current it can handle.

Dielectric isolation offers the best isolation and considerable density, but is also the most expensive. Through a complex sequence of processing steps, dielectric tubs are formed to isolate the power components from the rest of the chip. This expense will decrease as better base wafer-processing equipment is developed.

Packaging is an area that also needs further development as vendors deal with a lack of suitable standard packages. The need for conducting heat away from a chip becomes paramount when logic is combined on a chip — a problem that will get worse with new, higher power devices. Package design is expensive and not particularly glamorous. But it will receive increasing attention in the future, otherwise, vendors will have no home for their hot chips.

Considerable near-term gains are expected in monolithic smart power technology says Mackintosh Consultants Inc. of Natick, Mass. Their worldwide survey of smart power projects that, by 1990, development work in DMOS/CMOS will yield vertical, single-channel chips having voltage and current ratings of up to 1,000 volts and 80 amperes. The firm expects that worldwide attention will be directed toward CMOS/DMOS technology resulting, by 1990, in lateral multichannel chips that can handle up to 700 volts and 4 amperes. BiMOS is anticipated to increase its voltage to 250 volts. Junction isolation is expected to move beyond its present limitations to 1,000 volts, through the use of special charge-control techniques. □

minimum $500,000 production commitment from customers for product delivered over a period of 18 months.

Some chip makers are negotiating development and production costs based on obtaining marketing rights to the product. GE, for example, assumed all development costs for Trane's heat pump application. Trane benefits by eliminating component development costs and reaping the benefits of lower production costs providing the device takes off. Chaump points out that although his competitors will someday be able to buy the device, the design of the system is still critical; also, by the time Trane's competitors catch up the company will be developing another system.

Semicustom, cell-based design is expected to come to smart power in the next year or two, somewhat reducing the long development cycles and today's high costs of certain hand-packed designs. The benefits will not be as great as in conventional standard cell work; there will still be a great deal of manual design work required, cautions Lidow of International Rectifier. Mackintosh Consultants Inc. of Natick, Mass., expects that by 1990, 16% of smart power chips will be semicustom designs.

THE COMPETITION

After deciding to use smart power, "the next thing you have to do is decide who you want to marry," says Trane's Chaump. Indeed, vendor-customer relationships have to be exceptionally close in smart power designs. Often, the design is a custom one. If so, the customer must communicate effectively with the vendor so that chip designers fully understand the system environment. Once the design

is completed, there is no running off with the masks and getting it produced elsewhere; each chip maker virtually has his own process. The market has yet to see second-source agreements on custom, or for that matter, standard smart power products — except in the area of high-voltage, low-current components. Equipment manufacturers are warned: Choose someone you will want to be with for a long time.

Delco Electronics' West emphasizes the importance of a close working relationship with a vendor. "We sometimes don't always communicate everything we need to communicate on a piece of paper," he says. In developing a smart power chip, West cautions: "It's not: throw a spec over the fence and wait for the first silicon to come back and hope it works. A lot of dialogue needs to go on — a willingness to work together."

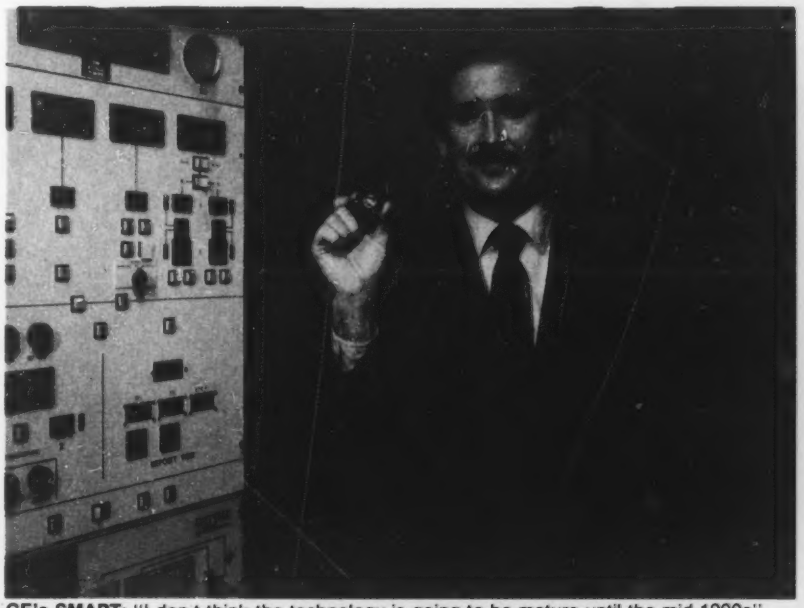
The approximately 40 smart power vendors worldwide range from established companies to start-ups; from firms steeped in power technology to those whose expertise is primarily in ICs; and from semiconductor giants to small specialty houses.

The major players today, according to Dataquest, are GE, International Rectifier, Motorola, SGS, Siemens and Siliconix. Other players include Mostek, Sprague, Supertex, Telmos and Unitrode. Start-ups include Elantech Inc., Integrated Power System and IXYS Corp. Besides those presently in the smart power market, many others are considering entering. "It's an open market today," says Dataquest's Bohn.

Among those eyeing the market are the Japanese. Right now, the Japanese are developing capability internally and watching how the market shapes up, says Bohn. Toshiba Corp., for example, has gained considerable experience developing smart power hybrids for applications such as the Bullet Train. It is unclear when Japanese firms will join the market, but some such as Mackintosh Consultants expect them to do so in 1987.

The companies that succeed in smart power will be the ones with expertise in power semiconductors, claim those vendors that have entered smart power from the power side. Dataquest's Bohn agrees. Smart power's biggest challenges, he feels, are in power technology.

Other factors are important as well, namely, financial commitment and involvement in key markets such as automotive. Motorola is considered, by many, likely to succeed for all these reasons. They have considerable experience in power devices, a very broad manufacturing base and background in the crucial automotive market.



GE's SMART: "I don t think the technology is going to be mature until the mid-1990s"

General Electric is a vertically integrated manufacturer, which allows it to develop products based on experience gained with in-house applications. They appear to be staying in hybrids, however; this may later remove them from a good part of the monolithic smart power market.

International Rectifier recently signed a five-year development agreement with National Semiconductor, forming a potentially good combination of IR's power expertise and National's analog IC capability. Many are looking at the alliance with interest to see how well it will work.

> The companies that succeed in smart power will be the ones with expertise in power semiconductors

Siemens benefits from having a broad manufacturing base and expertise in power semiconductor technology. The company has the resources, many believe, to continue and grow as a smart power player in the North American market.

It is almost impossible to project, at this point, which players will emerge in smart power's top 10. The next few years are critical, as firms enter the field and jockey for position before the expected shakeout during the early 1990s.

THE OBSTACLES

The obstacles to using smart power today all arise from its immaturity. High component costs, long custom development cycles, limitations on power and logic, and the lack of standard products and packaging are all factors that make using smart power difficult and sometimes risky. These will diminish as the technology progresses.

Although analysts such as Dataquest's Bohn prefer not to speculate about the near-term prospects for smart power, vendors will take a guess. Says Motorola's Janikowski, "The dam has got to break soon." He thinks 1987 will be the introduction year for many new products and 1988 will be a big revenue-growth year. Lidow of International Rectifier says that there will be "some blockbuster ICs in '87 but you'll be able to count them on one hand." He does not expect a lot of smart power devices on the market "until 1988 or beyond."

For now at least, equipment manufacturers will have to choose between waiting for the technology to mature and jumping on the smart power bandwagon early. Those that decide to use smart power within the next few years may be the ones to derive the greatest benefits from the technology by getting a substantial jump on their competition. Are the potential benefits worth the costs and risks? Only a detailed study of the particular application will answer that question.